Supporting farmers and agronomists to participate and learn about on-farm research to improve local farming practices

David Lawrence[1], Nick Christodoulou[2], and Jeremy Whish[3]

[1]DPI&F, PO Box 102 Toowoomba. Queensland, 4350, Australia. Ph. 61+7 46 881617 Fax. 61+7 46881197
email david.lawrence@dpi.qld.gov.au
[2]DPI&F, PO Box 310 St George. Queensland, 4487, Australia. email nick.christodoulou@dpi.qld.gov.au
[3]CSIRO/APRSRU, PO Box 102 Toowoomba. Queensland, 4350, Australia. e-mail jeremy.whish@csiro.au

Abstract
On-farm research is increasingly being used to answer practical farming questions, often by applying existing theories to real farming decisions. However, this pursuit of greater relevance has often led to compromises in research designs, unclear results and frustration amongst farmers and scientists. This paper reports on *'Doing successful on-farm research'* a workshop-based initiative that builds on the collective experience of the northern Farming Systems projects in north-eastern Australia, and the industry groups with which they have worked since 1995.*'Doing successful on-farm research'* subsequently provides a framework and a series of interactive activities to plan, conduct and interpret effective participatory on-farm research. The workshop approach helps people conduct on-farm research to suit their own needs and local conditions. It assists them to clearly identify their issues, develop research questions and decide the best approach to answer those questions with the appropriate rigour for their own situations. *'Doing successful on-farm research'* workshops in the grains, cotton, sugar and grazing industries have proven valuable because they address four potential deficiencies in on-farm research and Farming Systems RDE more generally: (i) variable participation of scientists and farmers in on-farm research; (ii) the lack of clear guidelines for effective participatory practice and on-farm research nationally; (iii) limited support for on-farm research beyond the intensive investigations conducted by RDE agencies; and (iv) limited support for industry and farmers to contextualise information and research outcomes for specific individual circumstances and faster adaptation of technology. This may be a major contribution to balancing the demands for both relevance and rigour in grains RDE to support better decision-making from the results on farms.

Key words
On-farm research, participation, relevance, rigour

Introduction
A more sophisticated braiding of the 'technical innovation' tradition of RDE and the more participatory 'human resource development' alternative has long been suggested to overcome the limitations of the Transfer-of-technology (ToT) model alone in Australian RDE (Russell et al. 1989). Indeed, increased participation of the people who implement innovations has become a common thread in recent arguments for better planning and conduct of agricultural RDE throughout Australia (Murray 2000; Dart 2005). Yet, the traditional ToT paradigm has continued to underpin the structure of most RDE agencies in Australia (Guerin and Guerin 1994; Lawrence 2006). Agronomists have wanted to maintain precision and control in their research (Carberry, Hochman & McCown 2004) and so continued to use the research processes afforded by their training until a new technology or practice was 'ready' for farmers to 'verify' (Stroud & Kirby 2000).

This traditional model has provided rapid use of new technologies and practices that have direct financial benefits, minimal complexity, acceptable risk, and are easily integrated into existing practices (Marsh 1998). However, this top-down approach has limitations when issues are complex and people have different understandings of the problem situation (Ridley 2005; Vanclay 2004). It may then create awareness of issues, but fail to translate this awareness into understanding or change (Blacket 1996). Indeed, people may have different values and not even recognise a problem, or may recognise a problem but require different or more specific information for their own situations. For example, the Grains Research and Development Corporation (GRDC) commissioned a review of RDE on nitrogen management, despite the fact, or perhaps because, it was one of the most studied topics in agriculture. This review identified a worrying gap between scientists' understanding of nitrogen management and actual farming practices, and recommended more farmer participation in RDE to improve the balance between 'understanding the science of nitrogen' and 'understanding how nitrogen was managed on farms' (Henzell & Daniels 1995). As McCown (2001) argued, there was an opportunity to move from a predominant 'policy research' paradigm that produces knowledge

before it is modified in practice and extended, to an 'action research' approach in which the production of knowledge for specific contexts occur as part of the research process (Onquist 1978).

Incorporating a participatory action research approach into the prevailing positivistic ToT culture of Australian agriculture presents significant challenges (Ridley 2005). Indeed, Petheram and Clark (1998) identified five key challenges to introducing such participatory methodologies to Australian RDE agencies: (i) to develop participatory models that fit the institutional settings; (ii) to convince traditional researchers of the methodologies' relevance, and the need for real participation by farmers and specialists; (iii) to develop means of achieving high levels of participation; (iv) to develop and access facilitation skills; and (v) to achieve recognition through outcomes on farms, peer review and publication. Clearly, the introduction of participatory RDE would be a learning experience for all involved.

In the grains industries, this 'push' towards a participatory approach has included a commitment to Farming Systems RDE and on-farm research that in the 1970s and 1980s developed within international development programs before gaining attention in Australia in the 1990s (Gibbon 2003; McCown 2001). Consequently, the Farming Systems projects in north-eastern Australia were developed to conduct participatory RDE and better collaborate with farmers and commercial agronomists to develop more profitable and environmentally sustainable farming systems in the region. While scientists had traditionally undertaken experiments on research stations or cooperating farmers' paddocks, the notion of on-farm research based on participatory action research (Zuber-Skerritt 2000) was introduced and became the central methodology of the projects to better understand and improve local farming systems. Key elements of such on-farm research were that the research would be: valued by all participants with genuine research interest and not simply a demonstration; done on farms with direct involvement of farmers and scientists in planning, execution and analysis; and each issue would have a well formed research question. This approach provided a way to investigate issues within real-farm settings and so study both biophysical issues and how they interact within normal management constraints and social interactions. Ultimately, it has demonstrated that on-farm research can help scientists and farmers to understand agronomic principles, provide answers to practical farming questions, and support managers to apply the resulting solutions to real farm decisions (Lawrence 2006). That is, on-farm research can be relevant and rigorous.

Research is a natural and instinctive part of being human (Hunter & Hayes 1996). Indeed, most farmers and agronomists test things on their farms in search of answers and a better understanding of how to overcome their local farming problems. There are also growing numbers of farmer groups and agronomists conducting their own on-farm research programs in Australia. Yet, developing processes that facilitate interaction and learning for both parties has been challenging and the participation of farmers and scientists in each others' on-farm research has been variable (Lawrence 2006). Consequently, many on-farm research initiatives have been criticised for emphasising 'relevance' to farming decisions at the expense of '(scientific) rigour' with poorly designed research and results that are, at best, hard to interpret (Carberry 2001). We have also seen on-farm research used primarily as an extension tool to demonstrate existing scientific understanding to farmers in their local environment but ignoring previous work and existing farmer and scientific knowledge (Lawrence 2006). In response to these criticisms, many on-farm research practitioners have concentrated on the 'how' of the research process by 'adopting' scientifically accepted experimental designs and applying these to all situations (Whish et al. 2003). The cost of this reaction has been to ignore the equally important 'why' aspect of research that establish its relevance, for example, understanding and forming research questions with participants and collectively interpreting results. Indeed, scientific rigour may be considered of secondary importance until the relevance of the research is established (Keen 1991). Consequently, there was an opportunity to support farmer groups and agronomists to conduct their own on-farm research.

Despite the growing numbers of projects run by RDE agencies to undertake on-farm research, there is a limit to how many of these typically 'intensive' scientific research activities that these projects can conduct. Yet, few 'packages' have been produced to support the on-farm research being undertaken by the wider network of farmers and farmer groups across Australia. Two notable exceptions were '*Test as you grow'* (Blake et al. 1998) for the grains industry in Western Australia that provide general templates and ideas for people, and the *'DOOR (Do your own research)'* project in the nursery industry in southern Queensland that advises on experimental designs to answer nurserymen's questions (Hunter & Hayes 1996). Indeed, many people doing on-farm research in the Farming Systems project of north-eastern Australia employed clear processes that they used in their own research, but much of this experience and understanding was in their heads. This tacit

knowledge was rarely collated or available for others to adapt and apply. While isolated materials such as *'Soil Matters'* (Dalgliesh & Foale 1998) provided help for topics like soil sampling, practical material to help people plan, conduct and interpret on-farm research, or even simple best practice guidelines for conducting on-farm research in the grains industries were conspicuously absent in the public domain. There was an opportunity to address this gap and develop activities to help farmers and agronomists to get the most from their on-farm investigations. Consequently, this paper describes the development and testing of the *'Doing successful on-farm research'* initiative to support farmers and agronomists to understand participatory on-farm research approaches, plan on-farm research to answer their questions to the standard they require, and develop their skills to use on-farm research to manage change on farms.

Methodology and methods

The *'Doing successful on-farm research'* initiative reviewed the experiences of the farming systems projects to develop 'best practice' for participatory on-farm research in a workbook to help farmers and agronomists 'navigate' and understand on-farm research and its potential to support change on farms (Lawrence, Christodoulou & Whish 2004). The approach merged the scientific notions of systematic research into a participatory action research framework on plan, act, observe and reflect (Zuber-Skerritt 2000) to encourage the contributions of different participants' knowledge and understanding of the research issues (Lawrence 2006). Workshops with interactive activities were then used to help participants decide and apply the most appropriate on-farm research methods to their own priority issues. Activities were developed to span a typical cropping season with a pre-season planning workshop, a mid-season tour of trial sites, and a post-harvest workshop to interpret any research results. These activities provided opportunities for farmers, agronomists, and the facilitators to share ideas and learn together. Some issues were resolved from existing information without any trials. However, where adequate information was not available, the process was developed to support participants to plan, conduct and interpret their own on-farm research trials. Consequently, workshops were structured around seven steps that reflect the basic process of scientific research (Box 1) and five key process features were used to support participation and learning amongst participants. This paper reports on twenty workshops with over 160 farmers and agronomists across the grains, sugar, cotton and grazing industries to understand the impact of the approach on participants' understanding of on-farm research and their ability to plan on-farm research that meets their own needs.

Box 1. The seven steps of *the Doing successful on-farm research* process

Step 1. Introduction to clarify all participants' expectations and the process

Step 2. Reflecting on participants experiences with on-farm research
- What are the key features of on-farm research?
- What are the advantages/disadvantages of on-farm research?

Step 3. Developing specific research questions
- What do you already know about your research issue?
- What are the features of a good research question?

Step 4. Reviewing existing information, past research and local experiences
- Can other people, here or outside experts and practitioners, already answer your research question?

Step 5. Selecting an appropriate research method
- What's important when selecting a research method?
- What are the common on-farm research methods and trial designs?
- Which method is best for you and your research question?

Step 6. Developing an action plan for the research
- What needs to be done, how, when and by who?

Step 7. Interpreting and learning from the research
- What are the results and what do they mean?
- Have you answered your original question?
- How your farming practices might change?

What have you learned about doing on-farm research?

Firstly, the workshops targeted people with authentic, not hypothetical, issues that they were already motivated to progress. That is, the process was designed to help people plan real research that would improve their management, and from the experience, better understand how to do practical on-farm research. The aim was not to promote greater use of on-farm research per se. Consequently, an interactive process helped people 'navigate' the basic research process (Box 1) with support from other participants while maintaining responsibility for their own decisions on how to address their individual research issues.

Secondly, a 'true workshop' approach (Lawrence 2006) was used to ensure participants had answers to their questions and progressed their on-farm research during the workshops. This is in contrast to 'chalk-and-talk' seminars that focus on examples, which may motivate participants, but not support them to apply the seminar's suggestions to their own situations once they return to their workplace (Lawrence et al 1997).

Thirdly, participation was encouraged at each stage of the research process with a transparent process to promote sharing of ideas and problems. For example, participants completed a step-wise workbook, but a summary of all steps for their issue was permanently displayed on the wall using a 'sticky-board' to encourage maximum interaction and provide a focus for wider group dialogue throughout the workshops. This iterative process built process rigour by challenging participants to justify their approach and encouraged suggestions from the group for each participant to consider in their decisions. For example, to clarify participants' knowledge before developing a research question, each participant is asked to document:

- What is your issue?
- Why is it important to you?
- What do you already know about the issue?
- What else do you want to know?
- What is the most critical information you want to know?

This justification was ultimately presented to the wider group for their inquiry in order to understand the problem and volunteer their experiences. Similarly, discussion of likely sources of further information from direct experience to propositional knowledge was encouraged. Each participant then decided whether they needed to conduct on-farm research. Again, the workshop facilitators contributed their own on-farm research experiences and used reference material in the workbook to highlight relevant propositional information such as the features of good research questions and common descriptive, experimental and quasi-experimental research designs. In each case, groups discussed these features before each participant developed a research question for their issue and proposed a research design to answer it. However, these proposals were again shared and reviewed with the group to provide each participant with some questions and suggestions to consider. This process was typically repeated two to three times to develop a research question, and twice for the research designs.

Fourthly, the workshops introduced the notions of different forms of research and people's different approaches to pursuing knowledge. For example, exploratory, applied and basic research are all valuable; and the relative costs and benefits of descriptive, experimental and quasi-experimental designs must be considered to make an informed decision on the most appropriate 'type' of research for an individual to pursue (Lawrence, Christodoulou & Whish 2004). Furthermore, people have a range of approaches to pursue and construct knowledge that include; tenacity, intuition, and authority, through to rationalism, empiricism and science (Graziano & Raulin 2004). Consequently, the workshops encouraged dialogue about the value of a more systematic approach to research, and the appropriate research designs for their research question and information needs. These final decisions remained with individual workshop participants who must ultimately decide what quality of answer they need for the question and the resources they have available. However, individuals were asked to describe and justify their choices to the wider group of workshop participants.

Fifthly, the workshops were designed to contribute to specific Australian Agricultural Training Package National Competency Standards and allow formal "accreditation" for participants seeking recognition of their expertise. However, more importantly, the specific learning outcomes of the Unit of competence, "RTE6503A – Design and conduct a field-based research trial" provided a useful structure to design, focus and evaluate the impact of the workshops with the following learning outcomes for participants:

Knowledge outcomes - Participants will understand and be able to explain:

1. key features of on-farm research
2. the advantages & disadvantages of on-farm research
3. the importance of defining a specific question when doing on-farm research
4. key considerations for design of on-farm research, including variability and its impact on OFR

Skills outcomes - Participants will be able to:

5. review existing information and knowledge for an on-farm research issue
6. develop clear and specific on-farm research questions
7. select an appropriate on-farm research method for their research question
8. plan and conduct successful on-farm research trials
9. analyse and interpret results of on-farm research
10. identify the implications of their research results for their farming practices
11. report and communicate their on-farm research

Finally, debriefing sessions at the end of each workshop and self-administered questionnaires with the first 115 participants were also used to further assess the impact of the process on their understanding and practice.

Results and discussion

Completed questionnaires (89% response rate) confirmed the overall usefulness of the *'Doing successful on-farm research'* workshops for the respondents, that is; farmers (31%), commercial agronomists (35%), RDE scientists from government and community-based natural resource management groups (34%). These respondents believed that *'Doing successful on-farm research'* workshops were a good investment because they were improving how RDE is done (92%). Each group believed the process had helped them to better understand on-farm research approaches (85%) and improve their on-farm research practices (89%), but they typically emphasised different aspects of these impacts:

1. Farmers typically appreciated the emphasis upon their aims rather than scientists interpretation of their needs, and a basic understanding of how to progress simple issues without the complications that professionals can introduce to gain more detailed data;

> *'(This is the) best farming systems day we've had here by a long shot and I think we've really achieved. It's the first time we've really achieved our aims'*
>
> *'(It's been) really good…to be able to put some thought processes behind it and get others ideas…clarification of ideas. I got a lot out of it…helped clarify and find somewhere to start… So, "right this is it, the best place to start"*
>
> *'When you're on the phone you always have ideas like "what's affecting my cotton?" and so for things like this topic I'm researching, it's about not complicating things for professional researchers to do…but keeping it focused. Today has given me an understanding and given me a kick-start on what to do and how to do it. It gives you a process of what to do and what to look for'*

2. Commercial agronomists often functioned as advisers and had variable research training and experience. Consequently, most retail agronomists with a sales function valued their new insight into the range of basic research designs that provide more statistically valuable quantification than the simple 'side-by-side' strip comparisons with visual assessments and un-replicated measurement of treatment effects that they commonly used. Conversely, some agronomists that routinely used the traditional 'completely randomised' and 'randomised complete block' designs with subsequent analysis of variance (ANOVA) concluded that qualitative descriptive methods may provide adequate answers to some of their questions and felt somewhat 'liberated' that full experimental designs may not be essential;

> *'Pre-today, I wouldn't have had a clue in the world to be honest. Today's given me a different thought process. Before today I'd have done a 'side-by-side' comparison), looked at it, scratched my head and said "yeah, it looks better"*

'I would have done, just 'put it on' and had a look, whereas this has given me 'where I'm aiming at?'…a yield response, and then methods and designs. And it's helped decide a side by side design with reps will be best. Pre-today, would have been just the ease of operation… to show farmer and just to see'

'It knocked out a lot of cobwebs, made in…not simple, but simpler. So it helped build confidence…understanding'

3. RDE agency staff had varying levels of experience with different research designs. However, professional researchers understood the concepts and typically valued the activities as an overview of research methods and a good engagement process for pooling groups' experiences and galvanising them into collective action.

'It was a general overview of how to do OFR, (so) very well worthwhile'

'As a researcher and consultant I am familiar with many of the issues and many are not directly applicable to me. However, I feel that the approach is excellent for involving farmers in their own farm improvement and also provides an opportunity for research and extension to obtain information from farmers'

'One of the things is we've always rushed in and taken the next step…put something in! Forcing ourselves…the discipline… to take the time out to ask "why we are doing this" and forcing ourselves to ask "what is the question", "why do we want to do it?" Personally, I've been struggling with this topic (stubble cover) for over a year and putting it off…but just sitting here today, it's come out quite easily. So, I've been thinking, its something we could do as a group each year…and so not just say lets do 'xyz", but forcing ourselves to go through this and having a process to use is good'

Despite these different emphases, the process promoted engagement between each group with 'lots of opportunities to participate and share ideas' with other people (98%). Ultimately, the majority of participants believed the *'Doing successful on-farm research'* workshops will help them improve the profitability (68%) and sustainability (65%) of their farming practices through the range of topics they addressed.

Learning to develop research questions and effective research designs
Participants across all industries consistently highlighted the critical impact of the workshops to be the support to develop clear research questions from their general issues, and to identify the most appropriate research designs to answer those questions. Indeed, 90% of survey respondents agreed (31% strongly) that the *Doing successful on-farm research* workshops improved their ability to develop specific questions for on-farm research. Similarly, 86% of respondents agreed (23% strongly) that the workshops improved their ability to select appropriate research methods for new questions. As both participating farmers and agronomists concluded;

Farmer: 'the biggest impact was writing that question. "What is it you're really looking for?" "What do you need?" That's a bit of an education for us and the people (agronomists) who are there to help us'

Commercial agronomist: 'I would have made a motza of it cause I was going to just put everything in…Zn, S and all. And I would have got it all complicated and just got confused. The real benefit was getting the question or the aim…making it more simple, easier'

Commercial agronomist: 'Before today, I wouldn't have had a clue. Now I know its how to find your direct question and get the answer…its been good. So, it's "find your target"

Commercial agronomist: 'The real benefit's the question, getting it straight what you want to do…not just an idea. Also (before today) I would have had half the paddock and half not. The approach is not new, but I was always thinking "its only a demo"…but maybe we should be doing

this more…trying to get more out of it. For example, Jeremy said we've got six guys here, so if we all did the same experiment, there's a lot of power there…And I'd never thought of that!'

RDE agency scientist: 'I'm happy to do it now. My main change in future will be asking the right question…knowing what I want out of it and not too many "and this's". Asking what question and getting the right question was the key (for me)'

Indeed, Box 2 illustrates the typical progress of workshop participants' attempts to turn general research issues into more specific research questions with the support of other workshop participants and a series of prompts to consider the object, setting, boundaries of the research information they require; and an assessment of the strengths and weaknesses of the commonly used research designs in Australia, that is, simple strip comparisons, paired sites, simple comparisons multiple controls, before-and-after (longitudinal) studies, monitoring for simulation, completely randomised designs, and randomised complete blocks (Lawrence, Christodoulou & Whish 2004). This development research questions was iterative and drew upon the group to seek clarification as to what each participant intended to do. In Box 2 the first participant went through 4 cycles of clarifying their question. The group questions for this example would have included: what do you mean by earliness? What type of insect damage? What are the boundaries of the trial?

The second example (Box 2) describes a modification to the process; some participants are not happy thinking about their research question as a complete sentence from the beginning. These participants consequently built their questions up by identifying key components: the object (or focus) of the research; the boundaries (or breadth) of the research; and what they intended to measure. These components were then converted into a question. As before the key questions from the group helped focus the research and remove ambiguity, or undefined statements.

Box 2. Examples of participants' development of a general research issue into a specific research question with an appropriate research design to answer it.

Participant 1

Step 1.	Issue: Earliness in Bollgard cotton
Step 2.	Question attempt 1: Is the earliness of Bollgard cotton affected by early season insect damage?
Step 3.	Question attempt 2: What is the effect of early season insect damage on the earliness of Bollgard cotton in St George?
Step 4.	Question attempt 3: What is the affect of early season sucking insect damage on the time to maturity of Bollgard cotton in St George?
Step 5.	Research Design The design was a randomised block design with 3 treatments and four replicates.

Participant 2

Issue : Impact of cattle on cultivation with respect to economics soil health, compaction, trade-offs between lower crop yields and income from cattle.

Object of the research: Yield loss from running cattle on cultivation and weight gain from cattle.

Boundaries: My farm, over the next 5 years.

Measurements: crop yield, and cattle weight gain over time.

Research question: Is the weight gain from cattle economically better than the yield loss from grain?

The design was replicated both spatially and temporally, using replicated exclusion zones within an existing cropping paddock.

Finally, an analysis of early evaluation data showed that the first 100 participating farmers and agronomists conducted up to 280 on-farm research trials a year. Participants also suggested that the *Doing successful on-farm research* workshops will help them avoid failures in up to half their trials. At a cost of approximately $5000 per trial (i.e. agronomists and farmers' time, resources and trial costs such as fertiliser, seed and fuel) this translates to a saving of up to $700 000 per annum on wasted research effort and resources alone, without any consideration of benefits from the information arising from successful trials. The magnitude of these figures confirms the potential of structured learning activities that utilise high levels of participation to integrate the diverse expertise of scientists, commercial agronomists and farmers in Australia's grains RDE.

Conclusion

The *Doing successful on-farm research* workshops are valuable because they address four deficiencies in the Farming Systems projects: (i) the participation of the team and farmers in on-farm research is variable; (ii) on-farm research comprises the central process of each project, but there are no guidelines for its conduct apart from the evaluation framework that acts as a prompt for effective participatory practice; (iii) there is a need to support on-farm research beyond the typically intensive investigations conducted in the projects (Whish, Lawrence & Christodoulou 2003); and (iv) better support industry and farmers to contextualise information and research outcomes for specific individual circumstances and faster adaptation of technology.

As a participatory process in its own right, the *Doing successful on-farm research* workshops have provided an engagement process with structured dialogue that supports the integration of scientific and practical knowledge from RDE agency scientists, commercial agronomists and farmers. Consequently, some farmers have sought greater scientific rigour through replication and randomisation in their trials, while many commercial agronomists and RDE agency staff are increasingly recognising the contribution of quasi-experimental and descriptive research designs. A primary insight from the workshops is that most participants' want on-farm research to test general principles in their own situations rather than develop new cause-and-effect relations. It appears that people may develop a comfortable understanding of cause-and-effect relations and use on-farm research to assess the value of these relationships to their specific individual situations. Indeed, some commercial agronomists are concluding that qualitative descriptive methods may provide adequate answers to some of their questions, and feel somewhat 'liberated' that full experimental designs with analysis of variance may not be the appropriate research method for all questions. As such, the *Doing successful on-farm research* process has developed more than single-loop learning about how to improve the most common on-farm research designs, and supported participants' reflection on their research needs and double-loop learning (Argyris & Schon 1996) on the most appropriate styles of research and research designs for these needs (Lawrence 2006). This may be a major contribution to balancing the demands for both relevance and rigour in grains RDE in Australia.

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