The Contribution of Participatory Research: On-Farm Research

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Key points

1. The issue of farmer participation throughout the research – extension process continues to challenge research scientists, but the benefits evident at the individual farm enterprise level are such that researchers cannot afford to ignore the opportunity.
2. Researchers need to develop processes and methodologies to ensure that their core research competencies can be deployed in on-farm participatory settings.
3. The application of new electronic technologies, especially Radio Frequency Identification for individual animal data capture, has the potential to revolutionise on-farm research.

Keywords: extension work, systems development, radio frequency identification, RFID, sheep

Introduction

Participatory research in agriculture may range from research and technology development (R&D), carried out on a research station with some involvement of farmers, through to genuine participatory research involving researchers and farmers working together. The latter involves the end-user in actually carrying out aspects of the research and/or in the development and evaluation of technology that is appropriate to commercial enterprises. Researchers often question the validity of the 'findings of on-farm participatory research' as they are more comfortable with the 'controlled' environment of the research station. However if research is to be applied appropriately on farms, it must go through a period of evaluation on-farm.

This paper summarises perspectives relating to participatory on-farm research, highlighting some opportunities that new technology is providing by considering five key areas as follows:
- Participatory research within the agricultural research enterprise (current situation);
- On-farm research compared with in-station research (options);
- A New Zealand example of on-farm research;
- New opportunities in on-farm research;
- Future models for participatory on-farm research.

Participatory research within the agricultural research enterprise

From research to best practice

The major driver for research in grassland and associated livestock enterprises is the development or evaluation of technologies or systems that will ensure adequate profitability of the enterprise, coupled with long-term sustainability of the grazing-livestock ecosystem. The general approach involves definition of key factors that impact on the performance and product output of the system, with the overall objective of assisting farmers to adopt and follow 'best practice' in managing their farming operations profitably. Thus participatory or on-farm research must be considered in the context of the overall objective of achieving best practice in farm and grassland management. The definition of 'best practice' may differ between different stakeholders and observers. However, regardless of the target, rural research is invariably focused on innovation and improvement within farm systems. They are the desired outcomes irrespective of whether the research approach is conventional (researchers operating external to the rural system to which new technologies are applied), or participatory (where farmers or their beneficiaries are involved in the research process). Irrespective of the manner in which research is conducted, process improvement is fundamental to the ability of rural ecosystems to adapt and change to meet new challenges.

Farming systems research, extension and learning, and the value of participatory research

The key elements of farming systems research (FSR) include a holistic approach, orientation towards the needs of defined target groups, and high levels of farmer participation and hence co-learning by farmers and specialists (Petheram & Clark, 1998). Recently, a combined Australia-New Zealand group (Barlow *et al*., 2002) outlined an approach to Farming Systems Research and Learning (FSRL) that incorporates on-farm research as a major component. They highlighted the fact that FSRL plays a role in ensuring that innovative technologies and practices will add value to farming businesses, but that it is the addition of the human element to traditional biophysical enquiry that makes FSRL a unique part of the innovation cycle.

The value of on-farm participatory research can be realised at several different levels. For example, it can enhance both the diffusion of technologies and the capacity of farmers to engage in a continuous pattern of innovation (Hildebrand, 1993; Johnson *et al*., 2003). The involvement of farmers at the formulation and design stage helps define overall priorities and identify factors and variables to be considered. It also helps provide a sense of ownership for the participants, and through involvement in trials, highlight issues that may impact on, or even compromise, the application of the technology in the wider practical on-farm situation.

Participatory on-farm research is especially relevant in grassland research, where the system involves the interaction of the grazing animal and the grassland environment. The system is, by definition, extraordinarily complex, with numerous 'inexplicable' interactions. In considering R&D that is relevant to grassland, it is critical to consider the purpose of the research. From a practical perspective, the different phases of research may be regarded as:

- *Component research*: defining the impact of changing a specific input component on the output (such as the effect of level of feed on milk production);
- *Novel technology or input*: evaluation of the impact of a specific technological input (such as a new pasture cultivar);
- *Whole system research*: defining the impact of a number of components on productivity within the context of the whole system (see section on the New Zealand example).

Figure 1 outlines a scenario for the research-innovation process through the phases from the research station to adoption on-farm. Early-stage, component or investigatory research is generally best managed on a research station where unforeseen difficulties can be managed, whereas the evaluation of the impact of a new technology on a system is best evaluated on farm. At all stages there are major benefits in involving farmers and other end-users in the planning and assessment.

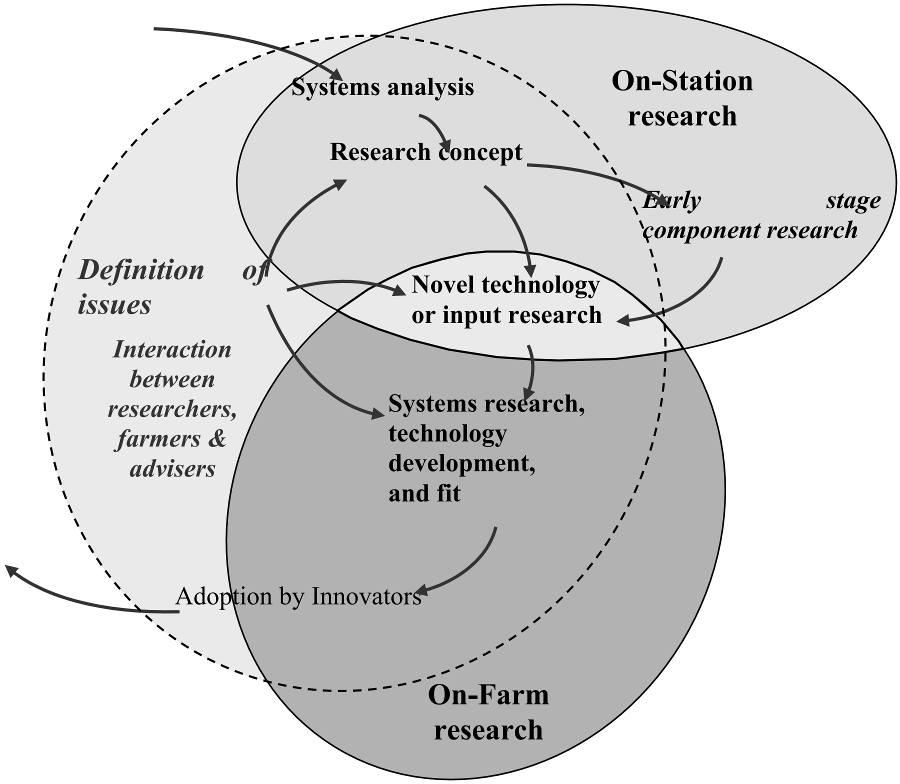

Figure 1 An outline of the research-innovation process (in part after Barlow *et al*., 2002)

On-farm research in the context of the system

On-farm research is particularly appropriate when designing experiments to challenge hypotheses about systems. Researchers commonly refer to this phase as validation, but the term is inappropriate. While the distinction between falsification and validation should be fundamental in all research, it is particularly pertinent in systems research where, in the absence of clearly defined hypotheses, the sheer number of observed variables can cloud the interpretation of the data. It is essential to develop well-defined hypotheses for on-farm research and establish designs and analyses to investigate the proposed key factor(s); otherwise the sheer magnitude of the observed variance and a lack of appropriate data could well obscure the effect of the factor under investigation. At another level, some investigators may regard it as simpler to collect large amounts of data via a type of 'population census' approach and then search for relationships. Irrespective of the manner in which an experiment or trial[6] is conducted, a second set of trials may well be required to test for specific effects.

[6] We distinguish between an experiment and a trial: a trial is essentially an investigation of a known technology, while an experiment implies a greater level of rigour involving investigation of unknowns.

A cost-benefit perspective

From a pragmatic perspective, the decision as to how and where to conduct research should come down to an assessment of the relative costs and benefits. Cost-benefit or investment analysis reveals the impact of speed to market on the returns from any investment. The issue of the time to market is a key consideration at an early stage of technology development in commercially-driven organisations, but time to market or time to adoption, is not usually a priority for research organisations considering the application of new systems in agricultural production. Consideration of this factor is an integral part of an active project management approach and helps highlight key factors, and so facilitating the identification of appropriate targets for investigation. Given the increased use of cost-benefit analysis in decision-making with regard to investments in agricultural research, and the application of project management approaches to R&D, we can expect this to change, albeit slowly.

On-farm or in-station research: challenges and limitations

A researcher perspective

Conventional research is (preferably) conducted on research stations because of the greater control scientists have on the research process, both at conceptual and operational levels. Therefore, the limitations of on-farm research are considered here in the context of those factors that scientists regard as likely to impact on the scientific validity of research, namely:

- The clarity of expression of the hypotheses and experimental objectives;
- The quality of the design, the experimental methodology and control of the variables;
- The quality of the management of the experiment (and the management rules);
- The quality of the data collected;
- The quality of the analyses;
- The quality of the interpretation.

The quality of the experimental design and of the methodology are especially important in on-farm research, as the ability of the researcher to control the environmental variables (including variations in management between farms) is limited, compared with that on a research station. However the limitations of data collection, the analysis of the data and the interpretation are also factors. Failures at any stage of this process can lead to inappropriate conclusions and a failure of the R&D process. This in turn can constrain the process of innovation, and at its worst discredit the role of R&D in the innovation process, and as a result, a formal R&D process may well be abandoned.

The end-user perspective

The potential for a direct impact of the findings of on-farm research on the farmer or end-user is a key benefit to be gained from on-farm participatory research. There is considerable literature around this issue that discusses the merits of various levels of farmer participation in research, particularly in respect of developing technologies that are more appropriate for intended users (and therefore more likely to be adopted), and/or improving the innovation process itself (Johnson *et al*., 2003). As noted above, key factors that scientists regard as impacting on the scientific validity of research are associated with the quality of the research. In contrast, the key factors that influence the value of research for the farmer or end-user are:

- The perceived importance of the function under investigation;
- The perceived reliability of the research;

- The perceived applicability of the research;
- The perceived cost-benefit relationship.

The perceptions of farmers are fundamental to achieving uptake and successful adoption of a technology or system. Thus a coherent value proposition is critical to convincing farmers of the potential value of a technology. In this respect, 'real world' on-farm research provides the opportunity for researchers to generate sound value propositions that will appeal to farmers. Consequently while there are major opportunities to generate real value from on-farm R&D where commercial farmers are directly involved, the scientist and farmer generally have contrasting value perceptions, with the farmer interpreting research findings in relation to one's own experience, particularly around integration of the technology into farm practices.

The research process

The following discussion of the research process allows the identification of the critical parts of the process that are amenable to on-farm, as distinct from on-station, research. The issues are highlighted mainly from the scientist perspective, which is focused largely on what is regarded as valid scientifically supportable data and subsequent analysis and interpretation.

Hypotheses and objectives

Clarity of thinking around both hypotheses and objectives of an experiment are fundamental to good research, but this is especially important in systems-based research, where the quantity and quality of data can greatly magnify the difficulty of objective analysis. The problems arise mainly from the complexity of the system and inherent interactions. This is a feature of systems research *per se*, rather than the location of the research (i.e. on-farm versus on-station). However in the experience of the authors, carrying out systems R&D on-farm in the 'real world' offers major advantages, and in this respect, investigators have shown that participatory models offer advantages over conventional research models in the determination of research objectives (Johnson *et al*., 2003).

Design, methodology and control of the variables

Why are researchers traditionally wary of on-farm research? The basic problem is the issue of control, in that it is very difficult to control the numerous variables introduced by operating in a commercial on-farm situation. This problem is well illustrated in the following expression from quantitative genetics:

$$\sigma^2 \text{ observed} = \sigma^2 \text{ environment} + \sigma^2 \text{ genetic} + \sigma^2 \text{ (genetics x environment)},$$

where σ^2environment = σ^2 (fixed and random).

Adapting this more specifically to the current situation, the following expression is appropriate:

$$\sigma^2 \text{ observed} = \sigma^2 \text{ treatments} + \sigma^2 \text{ environment (fixed + random)} + \sigma^2 \text{ (treatment x environment)},$$

where the fixed and random effects are considered separately.

Considering on-farm research in the context of these expressions, a key issue is the variance structure which is likely to be different to that encountered in on-station research. In the case of the latter, it can be expected that a greater proportion of the environmental variation will be allocated to the fixed component than in the situation with on-farm trials.

The above considerations also highlight the issue of replication. While there are several variations on the theme, replication of treatments in researcher-directed, on-farm R&D is often derived from replication across farms (including different managements), which virtually by definition will be more variable than sites within or even across research stations. This will result in a greater observed variance for on-farm trials and a greater random variance, as unassigned variance (that not due to treatments or fixed effects or those interactions) is allocated to the error or random environmental term. One solution to this dilemma may be to exert greater control over the site of the experiment by running the trials on a research station. However this may reduce the impact of the work in the eyes of farmers by restricting the perception of its applicability due to the control of variables that farmers may not be able to achieve in a commercial setting. An alternative is on-farm research with active involvement of farmers coupled with the collection of more data to compensate for the inherently greater variability around farm environments. In addition, a focus on the experimental design will be rewarding, by seeking to allocate variance to known fixed effects or seeking to define the factors that are important in generating the variation between farms.

Management and management rules

Participation of farmers in a study often results in variation in trial methodology due to managerial decisions that need to be made 'on-the-day'. For a study to produce conclusive or indicative outcomes, the consistency of farmer decisions across farms needs to be managed. Trials can be managed through the imposition of defined experimental rules at the outset. However, it is desirable to allow farmers some flexibility (within defined parameters), and accept variation resulting from commercial decision-making, and/or incorporate likely parameters resulting from commercial decisions into the experimental hypotheses and/or analyses. Accounting for such real-life variables is a challenge in rural systems research. This point is emphasised by Collins *et al*. (2001) who describe one of the constraints to on-farm research as the need to ensure that the co-operators -(farmer researchers), project facilitation staff and technicians, all understand the balance between the practical operation of the system and the need to collect accurate data. However, a pragmatic approach to dealing with the practical realities ensures that: 1) research is conducted in concert with the commercial realities of the farming operation; and hence that 2) the experimental results will have greater commercial relevance to farmers; and thus 3) can be expected to generate a greater buy-in and acceptance by farmers.

Data collection

The ability to collect adequate data (with respect to both quantity and quality) is a fundamental issue when comparing on-farm to on-station research. As noted previously, researchers often take the view that the results and interpretation of on-farm research are compromised due to the difficulty of controlling or managing the problem of the variation across farms. This has the effect of greatly increasing variability (variance in the statistical model), thus reducing the chance of detecting a statistically significant result. The normal response to such a problem is to propose an increase in the size of the experiment and/or a better definition or control of the environmental variables. In this context, the limitation is generally the ability to collect and manage additional data. Of all the factors that limit the use of on-farm trials, data collection is by far the most important as it impacts on the cost of collecting sufficient data and the accuracy of those data. However, new technologies can greatly enhance the process of data collection providing new opportunities in on-farm research. This is discussed in more detail in the section on new opportunities.

Data analysis and interpretation
The challenges of data analysis and interpretation in on-farm research arise from two sources, namely 1) the variation introduced by the range in environments (including the participation of the farmers in managing trials), and 2) the complexity of the interactions. However, where the process of data collection can be simplified, more data can be collected. Given the availability of such additional data, the feasibility of developing and testing more complex hypotheses is greatly enhanced. In particular, trials can be designed to ensure that factors that may vary across farms (including management) become amenable to investigation.

A New Zealand example of on-farm research: the CF2000 Scheme

On-farm research is ideally suited to investigations where the objective is to define the factors that influence outputs of the whole system, and then to use these findings to help evaluate new technologies and drive innovation at the farm level. A good example is the CF2000 scheme in the Clutha region of New Zealand. This case study provides an example of an approach to on-farm research where data were collected to allow the testing of a number of hypotheses. For example on New Zealand sheep farms, the lambing percentage (lambs weaned per ewe put to the ram) is a key factor that impacts on the profitability of sheep farming. While this may be 'widely known', the CF2000 study has helped reveal the impact, and also has highlighted other factors that are important in ensuring that an increase in the numbers of lambs born results in a greater profit. That is, on-farm research firstly highlighted the impact, and then secondly helped bring about real change in the industry in this region.

In the CF2000 study, a group of farmers, researchers, farm consultants, accountants and veterinarians lead by one enthusiastic farmer developed a package of measures to help define the factors that might be expected to impact on profitability on sheep farms. The concept was then sold to a wider group of farmers as an opportunity to develop benchmarking parameters that would enable them to compare their performance with that of others in their region. About 60 farmers took up the opportunity. Two highly respected advisers (a farm consultant and an accountant) had strong involvement, and assisted their clients with the interpretation of analyses. The involvement of the advisers, along with twice-yearly meetings and workshops, helped propagate findings among the group. Over time, several farmers shared experiences, and this free exchange of information became a further driver for change and innovation.

CF2000 parameters and analyses

In developing the scheme, several parameters considered likely to be important were identified. Farmers were responsible for their own data compilation although they had assistance from their farm accountant (who would have required much of the physical and financial data to complete the financial accounts for taxation purposes anyway). The approach involved the collection and compilation of base data and additional performance data (*) as in Table 1.

Over the few years that CF2000 has been operating, several types of analyses have been performed. Regression analysis has been used frequently (including analysis of covariance), to present an overall regression line for a relationship (as below), and highlighting the performance of individual farms has provided a potent stimulus to discussion.

Table 1 Data recorded by farms participating in the CF2000 scheme

Farm classification data:	Area & class of land, soil type, sub-division, water supply etc.,
Physical input data:	Breed, numbers, and age classes of sheep (& other stock) *Fertiliser use: timing & type *Pasture renovation: timing & type *Feed conservation: silage, balage or hay *Feed purchases: timing & type *Use of anthelmintics, vaccination & animal health treatments
Physical output data:	Numbers & weights of products sold (meat, wool, livestock) *Timing of sales *Quality parameters, including sex of lambs
Financial data:	Inputs: Maintenance, fertiliser, seed, labour, contractors etc., Outputs: Returns as for physical outputs
Performance parameters:	*Weight & condition of ewes at key times (mating & weaning) *Pregnancy rate & litter size (at ultrasound scanning by ewe age etc.), lamb deaths, weaning rate *Ewe deaths (number & timing) *Live weights & weight gains of lambs (monitor mobs)

Generally statistical analyses were performed using farms as replicates, with farms grouped as 'treatments' as appropriate to test the effects of different factors (e.g. breed or strain of sheep, ratio of sheep:cattle, stocking rate within land class etc.) on performance parameters and the relationship between physical and financial outputs and profitability on performance parameters and so on. For the farmers, the most interesting findings around the performance parameters included the:

- impact of breed or strain of sheep on litter size at ultrasonic scanning during pregnancy;
- relationship between litter size and live weight at mating;
- relationship between litter size and the date by which all surplus lambs are sold;
- seasonal pattern of ewe deaths;
- variation between (and within) farms in the growth rate of lambs.

In many cases these findings influenced the behaviour of farmers. The involvement of an experienced farm consultant to assist with interpretation and to provide the opportunity for the farmer to discuss ideas was also important. For example, the realisation of the:

- impact of breed or strain on litter size (by ultrasonic scanning) resulted in some farmers evaluating (and in many cases) changing to other breeds or strains of sheep;
- effect of liveweight at mating changed the way farmers managed ewes after weaning;
- impact of feed supply available for ewes in the month or so before mating (as affected by the competition from surplus lambs being grown to higher weights) lead to farmers becoming more focused on lamb growth rates and selling lambs by defined dates;
- seasonal pattern of ewe deaths resulted in farmers sorting ewes by litter size to enable preferential management of ewes carrying triplets in the period prior to lambing;
- variation between farms in lamb growth rate resulted in some farmers changing grazing management of lambs after weaning (including sowing newer pasture cultivars).

In combination with analysis of performance, analysis of profitability (gross margin/hectare) proved very helpful to farmers, particularly in relation to gross margin as a function of four factors, namely 1) the average weight of meat sold per hectare; 2) average weight of lambs sold per hectare; 3) pattern of sales of surplus lambs, and 4) the average litter size of the flock.

As a consequence of their involvement in CF2000, and the identification of some of the key factors impacting on profitability, the farmers involved became more confident about evaluating new technologies and looking at new ways of managing their businesses.

New opportunities in on-farm research

Constraints to the increased use of on-farm research

Background
The CF2000 experience highlighted the value of participatory R&D, on-farm analysis and benchmarking. Having shown some of the benefits and identified the critical components of the research process, the challenge now is to target the key constraints to the increased use of on-farm R&D. The premise is that a greater use of on-farm research will increase levels of participation, and hence can be expected to facilitate the process of innovation and the adoption of improved practices by farmers.

The development of research objectives
The joint development of the research agenda is a critical part of ensuring that all parties are engaged in tackling the same objective. A shared goal that all stakeholders have 'bought into' provides the commitment required to overcome the difficulties and constraints encountered during the research process.

Farmer appreciation of issues in research design
The formulation and design of research in agricultural systems is an advanced skill. Even on research stations, these skills may be under-developed and research compromised, hence the involvement of professional biometricians in the design process is essential. An understanding of design issues is particularly pertinent in participatory research. Thus researchers must ensure that farmers are aware of the nature of the research process, and the necessity for some constraints on the research design. When farmers are aware of the factors involved in robust experimental design, they can be expected to have a greater appreciation of the constraints. Two good examples are the necessity for appropriate replication in experiments, and the classical trade-off in progeny tests between slaughter of animals at an appropriate time versus slaughter at the same weight.

Perspective
A key constraint in the use of on-farm research is not a lack of researchers who are willing to be involved, but rather a shortage of researchers who can:

- develop processes and experimental designs that can leverage on-farm research to provide scale and ensure faster uptake of research findings;
- design research processes compatible with commercial farming practices;
- communicate research processes, and obtain buy-in from farmer stakeholders;
- interpret the results in ways that are both meaningful and relevant to the farmer.

Data capture technologies

The above discussion focused on areas where the skills of researchers can be effectively deployed in on-farm participatory research programmes. While researchers must develop processes and methodologies to engage farmers in such programmes, new electronic data capture technologies will play a critical role in expanding the opportunities for on-farm research. Many people see a paradigm shift that will transform on-farm livestock and associated grassland research. Key technologies include Radio Frequency Identification (RFID) systems, Geographical Information Systems (GIS), associated electronic data collection, and other related technologies (e.g. novel technologies that will enable cost-effective collection of data on soil and plant conditions and pasture growth). However, the following discussion is confined with respect to RFID systems.

Radio Frequency Identification systems as a tool for improved data collection
RFID systems are being rapidly deployed in a range of logistics and product tracking situations (Want, 2004), including livestock identification and traceability. Specific benefits of the application of RFID systems will be an enhanced ability to rapidly capture data from large numbers of individual animals, and to retain records in an easily retrievable form for subsequent analyses (e.g. intensive recording of individual milk production, live weight, health and reproductive data etc.). Thus RFID will provide the means to radically change the scale of on-farm research.

Why are new data capture technologies are so important?
The use of such tools will allow for the collection of data of a quality required for formal analysis through conventional research processes, within a commercial setting. Given appropriate guidance by researchers, electronic capture of data effectively raises the ability of on-farm managers, to record data of a quality previously captured by highly trained technicians and research staff.

In summary, the application of RFID systems will greatly facilitate the collection of animal data. The impact of this technology is considered to be much greater for on-farm research than for on-station research. Table 2 presents a summary of the comparative importance of issues, advantages and disadvantages of on-farm R&D compared with on-station R&D, highlighting the impact of the application of RFID systems.

The impact of new data capture technologies on participatory research

The major limitation to research is money. Hence regardless of whether research is on-station or on-farm, the balance of the cost-benefit equation is dependent on the comparative benefits of the two alternatives. As discussed previously, researchers often take the view that the results and interpretation of on-farm research are compromised by the difficulty of controlling or managing variation on commercial farms, i.e. that on-farm research involves new variables and management challenges, such that there is a risk that the research will lack the scale required to produce statistically valid and useful research outcomes. Given the use of RFID technology and associated systems, the key question in considering any R&D project is whether the benefits of on-farm research are outweighed by the risks. In this respect, the key benefits of on-farm research (across many farms) include the following:

- opportunity to look at whole systems, various environments and technology interactions;
- the 'sell' opportunity to create fast and significant adoption (in this sense, word-of-mouth will always be the most powerful selling tool);
- farmer participation helps drive support and understanding of the contribution of research.

In most cases it is the data limitation that inhibits or compromises on-farm research. Hence many of the negatives around the on-farm research approach can be reduced by the collection (and analysis) of more (quality) data. In this context, RFID is an enabling technology. By utilising RFID systems, the potential benefits of participatory research for whole systems research over that of research based on research stations can be realised.

Table 2 Issues, and advantages/disadvantages of on-farm compared with on-station R&D, with particular respect to the impact of the application of Radio Frequency Identification (RFID) systems to collect animal data

Design & management		
Clarity around hypotheses and design	Greater importance for on-farm research, due to the need to communicate & engage farmers	
Control over experimental management and process	Less control with on-farm R&D, but RFID reduces the disadvantage of on-farm research	
Opportunity to investigate many factors determining performance of system Opportunity to integrate technologies into whole systems	Greater opportunity through on-farm than on-station R&D	Greater ability to capture data means more factors can be considered in on-farm research with RFID than without
Data analyses & interpretation		
Number of parameters (complexity) to be accounted for (or not accounted for) in the statistical analysis Chance of producing statistically significant results	More complexity on-farm means that there is a lesser chance of producing statistically significant results	RFID facilitates data collection so that the quality and quantity of on-farm data are enhanced
Farmer involvement & long-term benefit		
Farmer participation and support Opportunity for interactions with farmers around the technology Expected overall level of adoption & rate of adoption	Much greater through actual involvement of farmers in the R&D	Enhanced impact by application of RFID as more meaningful R&D is achievable

Potential future models for participatory on-farm research

In considering the opportunity for the further development of on-farm participatory research within livestock-grassland systems, it is interesting to outline aspects of the innovation process in other industries, and then compare these with those within the grassland sector.

On-site research within the manufacturing sector

Most ground-breaking research in manufacturing is conducted and funded by large multi-national corporations, with some basic research conducted within Universities. However, in most manufacturing sites, process engineers typically assume responsibility for on-going process improvement and innovation. While ground-breaking technologies or new systems are frequently sourced from outside the company (e.g. from the multi-nationals, or specialist suppliers), process engineers possess the detailed knowledge of company processes, constraints and targets, and have access to the statistical tools to research and implement process improvement and innovation.

On-site research in seed and vegetable production

In a similar manner to the manufacturing sector, large-scale vegetable production often relies on external sources for significant innovation in processes and in the development of new cultivars. However, scientific skills in the evaluation of new varieties and methodologies are typically found only on the largest of commercial vegetable production operations. The suppliers of key inputs, such as seeds and fertiliser, often undertake the role of process improvement. In this respect, a service commonly provided by the seed companies is that of the establishment and management of research trials of new cultivars and varieties for growers. A New Zealand company (Xenacom) has developed a trial management and traceability software application for the seed industry to accelerate the process of development and evaluation of new plant varieties. The package provides a system to record commercial trial data using standardised evaluations, thus facilitating the selection process and enhancing relationships with breeders and growers.

Developing new 'on-site' participatory models for grassland farming

Background

In most parts of the world, commercial grassland farming is dominated by family or owner-operator businesses. The characteristics of such businesses include:

- production systems that are too complex for simple trials to yield useful information;
- few significant external inputs, which could be used to subsidise the provision of research skills (as in the vegetable grower example above);
- the skills required to operate the business do not rely on formal research skills, so that innovation conducted at the farm level is not of a formal research standard (in contrast to the process engineer example above), and hence on-farm stakeholders have difficulty engaging in participatory research programmes;
- detailed performance data (e.g. individual animal data) are unlikely to be required to operate the farm, but such data are vitally important in the more formal R&D process.

The implications of the above are such that development of participatory models in on-farm livestock-grassland research is not a simple extension of current systems. The availability of new tools that will greatly increase the capacity to collect data, coupled with the opportunity to devise much more powerful experimental designs, can greatly increase both the power and scale of on-farm research. This requires the involvement of skilled biometricians with an understanding of biological variation, who can design, analyse and help interpret experiments in association with the end-users (Johnstone, 1998). New technologies will allow for far greater levels of end-user participation in research than has previously been the case.

On-farm as an extension of on-station research

Several on-farm sites can be used as replicates for on-station research programmes, using technology to facilitate data capture, and with formal experimental design and analysis of results supplied by on-station experts. Data can also be transferred regularly back to the researcher for monitoring. The obvious potential benefits include a more powerful experiment, with increased scale at less cost, plus the enhanced participation of farmers and their likely acceptance of the relevance of the research.

Collective on-farm

A development of the research model above would be where farmers themselves initiate the research process, engaging researchers to provide key skills (experimental design and data analysis). Thus, farmers would outline the objectives of the research and have the key responsibilities of management and data collection.

‘Distributed’ research model

The widespread use of new RFID technologies will facilitate the development of a potentially much more powerful research model. Where several farms routinely capture data via automated RFID equipment, farms will build their own databases of farm performance information. These distributed databases can then provide the data source for a ‘distributed’ research programme. Data capture is a by-product of the day-to-day farming operations and is not an added burden or requirement of the production system. The potential for such a model is exciting, as it provides minimal constraints on the farming operation, but allows for a wide range of on-going research programmes to be conducted. However, special care needs to be taken in the formulation of hypotheses and design of experiments based on a distributed model. There are situations where the large quantity of data will not compensate for biases that may exist in the data capture process, and systematic bias is a danger for such distributed models. Thus without full participation of both scientists and farmers at all stages of the process, the research outcomes may well be compromised.

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