McCown, R. L., Freebairn, D. M. and Hammer, G. L. (1992) A framework for research on improved management of agricultural production systems. In: *Looking Back - Planning Ahead*. (Eds K.J. Hutchinson and P.J. Vickery), pp.214-17. (Australian Society of Agronomy: Parkville, Vic)

A framework for research on improved management of agricultural production systems

R.L. McCown, D.M. Freebairn, G.L. Hammer

Agricultural Production Systems Research Unit, PO Box 102, Toowoomba QLD 4350

Summary. The combination of the continuing cost-price squeeze and pressures for more environmentally-friendly agriculture makes farm management increasingly difficult. Assistance to farmers in decision making poses a challenge to agricultural R&D professionals. What is needed does not call on our undisputed capacity for generating new technology. What may be useful are 'systems' concepts and methods that Australians have played some role in developing, but which have not been widely used in Australian agricultural R&D. This paper describes how a new research unit plans to build upon these for R&D aimed at improved management of dryland agriculture in the subtropics.

Introduction

Looking back at agricultural production research over the last 40 years, a number of important generalisations can be made. An enormous contribution has been made to the creation of the technology which underpins our efficient production systems. In achieving this, research has been primarily reductionist and propelled by the vision of scientists in their respective disciplines. The direction taken was strongly influenced by the circumstance of cheap fossil fuel. The setting of priorities for publicly-funded research was left almost entirely to scientists, and there was frequently a low degree of accountability for research outcomes. For most of this period, both officialdom and the public supported steady growth of the research budget as an investment in the future of agriculture and the nation.

Things changed especially rapidly during the 1980s. Farmers began to feel, in addition to the relentless cost-price squeeze, the pressure of a public concerned about the destructive, wasteful, and dangerous aspects of agriculture. The problems of land degradation, the high cost in fossil energy, and chemical hazards to producers and consumers were seen by many as the legacy of scientific agriculture. Research organizations began to experience the effects of 'economic rationalization' in government as well as a much more critical community attitude toward science in general. Core public funding for agricultural research declined and a greater proportion of funds have become competitive based on prospects for benefits to industry and/ or the public.

During this period, criticism from two agricultural professional quarters was heard. Economists periodically pointed out that most of agricultural research was conducted and reported without any sign that adaptation to an economic environment had been considered (1). In addition, a 'soft systems' voice was heard for the first time (initially overseas as Farming Systems Research) pointing out the general failure of agricultural researchers to consider adequately the human aspects of agricultural systems in research and extension. Farmers have concerns beyond the latest technology. Furthermore, they have not only a perspective and knowledge of agriculture that differs from that of researchers, but one which is demonstrably valuable in the process of generating useful research products.

Agriculture in Australia faces a period of unprecedented challenge. To remain competitive in world markets, and even to compete successfully with imported commodities in the domestic market, will require continued improvements in production efficiency. A current rule of thumb on the Darling Downs (P. Wylie, pers. comm.) is that increasing yield by 15% will double profit; a similar decline will eliminate it. The pressure for more sustainable farming systems and safe chemical practices will only increase. Successful managers will increasingly be those who most effectively deal simultaneously with multiple management goals which are at times in conflict. In this increasingly complex environment, there is a growing need for improved aids to planning and decision making.

A new production systems research unit

Industry, government, and research organisations are demonstrating a new interest in a systems approach to improving management of agricultural production. In Queensland, the Department of Primary Industries and CSIRO's Division of Tropical Crops and Pastures have recently established a joint research team, the Agricultural Production Systems Research Unit (APSRU). This unit, located in Toowoomba, Queensland, has a primary mandate for the dryland cropping region between Clermont, Queensland, and Dubbo, NSW, but has national projects as well.

The team was assembled on the basis of common interest in systems research, and achievements in modelling crops and cropping systems. The Unit's mission is 'to benefit subtropical Australia and the nation through client-oriented agricultural systems R&D leading to improvements in production efficiency, risk management, and sustainability'. APSRU's central goal is to provide decision support to producers and other managers in the agricultural system of this region. The remainder of this paper outlines a framework for doing this and discusses its rationale and key aspects of its evolution.

APSRU's research framework

The conceptual starting point is the 'systems approach' which during the 1970s began to influence agriculture in two directions. Firstly, the farming systems research approach (FSR) evolved among Western agriculturalists trying to improve performance of farms in the Third World. The emphasis in FSR is on analysis of the system (including ecological, economic and social aspects) to target R&D efficiently and design efficient information transfer. It features involvement of farmers in both the analyses of need and the research. Secondly, the advance of systems research in the other direction featured simulation modelling as a tool for comparing alternative strategies. The FSR emphasis on scientists studying farmers and their circumstances has seemed irrelevant in developed country agriculture, because of the presumption that scientists and farmers there see the world in much the same way. Scientists know what farmers need and farmers readily take research products and fit them successfully into their production systems. These presumptions have been severely challenged in Australia in recent years, by advocates of a more people-oriented systems approach and by representatives of industry who have a new concern about value for the research dollars now that industry is footing more of the research bill.

Figure 1 shows a framework that brings together the client focus and on-farm research of FSR, and the power of a modelling approach to integrate and exploit scientific knowledge. The top half of the figure is a generalisation of the much-reproduced FSR diagram of Collinson (1). Figure 1 extends the list of managers beyond producers to include a number who share with farmers either the problems of uncertainties of weather and yields or the tension between the exploitation and conservation aspects of farming. The central goal of APSRU is to provide potentially valuable new strategies and appropriate information in an appropriate form to client managers for both strategic and tactical decisions. To ensure an appropriate decision support outcome that is valued by the client, an analysis of information needs and opportunities for decision support in conjunction with potential clients must be conducted initially. Analysis of the decision making processes of these various managers is an important area of research for a multi-disciplinary team led by a socio-economist.

APSRU's core expertise and research technology is in crop and soil management and in the computer simulation of crop production systems. Models of crops and soil processes make it possible to research many aspects of cropping systems by conducting simulation experiments on the modelled system. This approach to research on complex systems where risk is an important aspect of performance has been the key to many of the great post-war engineering feats, and has become known widely as operational (or operations) research (OR). This contains the systems analysis and modelling techniques of the 'systems approach' familiar to agricultural scientists since the early 1960s. Although many of our specific techniques differ from the standard ones used in most of industrial OR, we believe that the similarities are too great to avoid using the OR label. In this we disagree with Spedding (6). By any name, it has taken until recently for crop and soil models to achieve an accuracy of prediction with affordable model inputs for such an approach to become a serious option for client-oriented research on crop and soil management.

The operational research approach entails comparing the simulated performance of various relevant configurations of the crop production system to quantify risk and to identify optimal management options (Fig. 1). This can be done for any location for which long term rainfall data exists. Decision analytic methods and other economics tools are used to interpret outcomes and identify optima when risk is important.

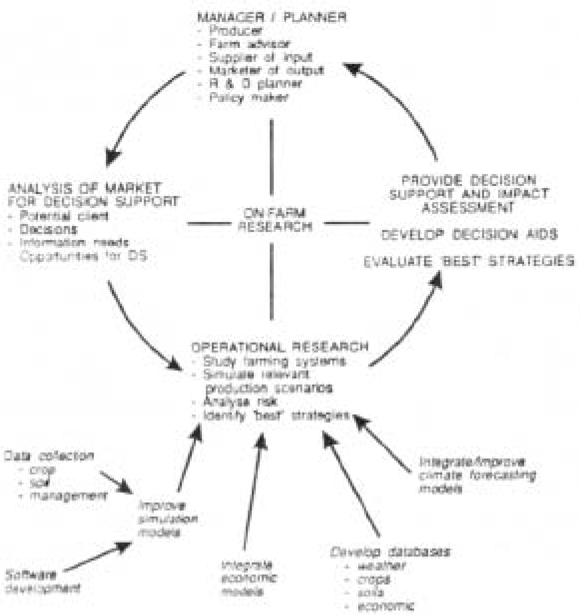

Figure 1. Framework for client-oriented R&D aimed at improving management of production and associated processes in an agricultural system.

Continued improvement of simulation models is necessary to improve APSRU's operational research capability (Fig. 1). At present wheat, sorghum, sunflower, peanuts and maize production can be simulated. Development of models of chickpea, soybean, mungbean, and barley are in progress as are improvements to the simulation of N supply, especially from non-fertilizer sources. Our cropping systems model, PERFECT (5) developed for this region, enables sequencing of crops and simulation of the effects of tillage system on the hydrology and soil erosion. A major software improvement is underway by combining features of PERFECT and AUSIM (2) under a user-friendly management 'shell'.

Database systems for model input data and production data for calibrating and testing are being developed (Fig. 1).

One of the most promising opportunities for reducing risk in production decisions is the use of climatic forecasts based on the southern oscillation. The operational research framework enables the economic value of forecasts for various decisions to be assessed and decision strategies for incorporation of this information to be optimised (2).

The operational research capability will continue to increase as a result of improvements and new developments, but current capability enables development of decision aids now. For certain problems and clients, output of the OR activity provides decision support directly. In the case of farmers, decision support is provided by the development of products that they can use to aid their decision making. While it seems obvious that micro-computer software is a medium with merit, the evidence is that it may he a long time before this is the appropriate way to communicate with any but a few farmers. In the framework that we are using, the matter of form of communication is determined in response to findings of the market analysis research. Even when a computer is appropriate, the software needed is very different to that used in operational research.

WHEATMAN (7), a decision aid for wheat management for this region, sets a precedent as a product developed by the process of Figure 1. Selection of a cultivar, at a location, for a given planting opportunity relies on probabilities generated from yields simulated using historical weather records for a nearby location for many planting time-planting conditions scenarios. Natural extensions of this type of aid include addition of crops, both winter and summer, and elaboration of rules for crop choice and inputs.

Inclusion of sustainability considerations in production decision aids has yet to be attempted. PERFECT has been developed as a tool for simulating soil erosion and assessing the productivity decline of the clay soils of this region. However, a clarification of a path for effective decision support awaits research, just beginning, on farmer attitudes, preferences, and awareness regarding land degradation issues.

Discussion

In general, we are cautious about decision support systems. With current limited understanding of (a) farmer decision-making processes and (b) the impact of existing decision aids, it is heroic to assume that formal, complex, decision aids have a big future in agriculture. We are also cautious about the process in Figure 1 for developing it. While we believe the OR approach is a powerful, as yet underutilised, way to apply resource data and scientific understanding, it provides only one perspective of system performance. It is essential that the procedures used in Figure 1, especially in the market analysis and development of decision aids, capture other important perspectives by the involvement of potential clients as partners in the process.

Systematic systems research has been on the agricultural agenda for 30 years. Progress has been sporadic and fragmented. One of our stated goals in APSRU is to demonstrate an effective and reproducible R&D technology for improving management of production systems. While nothing we are attempting is new, attempts to 'pull it all together' are remarkably rare. We believe that this project itself is an important experiment.

References

1. Collinson, M.P. 1982. Michigan State Uni, International Development Paper No.3

2. Hammer, G.L., McKeon, G.M., Clewett, J.F., and Woodruff, D.R. 1991. Conference on Agricultural Meteorology, National Committee on Agrometeorology, University of Melbourne. pp. 15-23.

3. Kingma, O.T. 1982. Proc. 2nd Aust. Agron. Conf., Wagga Wagga. pp. 350-356.

4. Littleboy, M., Silbum, D.M., Freebaim, D.M., Woodruff, D.R., and Hammer, G.L. 1989. Queensland Department of Primary Industries Bulletin QB89005.

5. McCown, R.L. and Williams, J. 1989. SSA IMACS 1989 Biennial Conference on Modelling and Simulation, Canberra.

6. Spedding, C.R.W.1980. Operations Research in Agriculture and Water Resources. pp. 67-77.

7. Woodruff, D.R. 1987. WHEATMAN. Queensland Department of Primary Industries Project Report Q087014.