A SYSTEMS APPROACH TO DEFINING AGRONOMIC PROBLEMS AND SETTING OBJECTIVES FOR RESEARCH

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ABSTRACT

Research objectives are discussed in relation to the national objective of increased agricultural production, and the more complex objectives of individual farmers who are the direct consumers of research output.

A systems approach is defined as the application of the scientific method to the study of complex systems. The distinguishing features of problem orientation, an inter-disciplinary approach and the use of mathematical models are discussed. It is suggested that agronomists need to become involved in order to provide convincing evidence on the use of a systems approach for defining agronomic problems and setting objectives for research.

INTRODUCTION

A "systems approach" is often viewed as something different to traditional approaches to research. It is, however, nothing more than the application of the scientific method to the study of complex systems. It provides a framework within which traditional research activities can be carried out with greater overall efficiency. The distinguishing features of a systems approach are firstly, problem orientation; secondly, an inter-disciplinary approach; and thirdly the use of mathematical models. The first is probably the most important as it leads directly to the other two. Before examining these features in detail, we should first consider the overall objectives of agricultural (and agronomic) research in New Zealand.

The obvious facts are that the New Zealand economy is largely dependant on agricultural production, a significant proportion of which is derived from grazed pastures Increased agricultural production is viewed as a national objective and, given that the majority of agricultural research is funded by Government, this would also seem to be a reasonable objective for research. However, national objectives can only be achieved through the collective action of the farmers who own and control the individual production units. Their objectives are complex and not necessarily compatible with national objectives. However, as farmers are the direct consumers of research output, their objectives must be taken into account. The current gap between research and the consumer is a matter of some concern. For example, the New Zealand Institute of Agricultural Science devoted their 1976 Convention to the topic: "Bridging the Technology Gap" . One of the implications is that research objectives may have to consider increased agricultural production in wider terms than just physical or monetary measures of efficiency (Dillon, 1973).

PROBLEM ORIENTATION

Problem oriented research is concerned with answering questions in order to better pursue a given set of objectives. Because the farm is the basic production unit, the most of research should at least be initiated by problems and opportunities at the farm level. This does not imply that *all* research projects should be directly concerned with solving on-farm problems. Much research can be seen as improving the basic stockpile of knowledge which is drawn upon to solve such problems as and when they arise. There is, however, a danger that "improved understanding" becomes the paramount objective for many researchers, and "understanding" unrelated to "purpose" is a questionable objective (Spedding, 1975).

The situation seems to arise from the fact that research needed to gain a better understanding is essentially analysis rather than synthesis. Analysis is based on fragmentation and simplification or the original complex system in order to define relatively simple hypotheses that can then be tested by standard procedures. The results of analysis tend to yield hypotheses for further analysis. As analysis (and fragmentation) proceeds, it is not difficult to see how it can become self-fuelling in terms of objectives, and isolated from the original question.

A systems approach would attempt to ensure that the objectives and results of research at all levels, were periodically addressed back to the original production systems and problems. This synthesising process is the only basis for deciding whether analysis is creating the right sort of knowledge. If a systems approach was being followed, one would expect to see in a significant number of published papers, a reference to the problem that initiated the line of research, and an indication of the value of the results. The "Notes for Contributors" for the proceedings of this Society, for example, suggest that the "Introduction" should clearly indicate the purpose for which the research was undertaken. In many of the papers, "purpose" seems to have been interpreted very liberally.

It is probably unrealistic to expect that all scientists be skilled in both analysis and synthesis. Thus the responsibility for achieving problem orientation in a research programme will be more with research leaders and directors. However, the individual scientist should be concerned with the usefulness of his research, and in many cases he will be the person best qualified to interpret his work in relation to production opportunities.

AN INTER-DISCIPLINARY APPROACH

The fragmentation that occurs in analysis tends to be along disciplinary lines. A discipline is simply a convenient organisation of knowledge for the purpose of study, not for the purpose of solving problems. Production problems only arise in relation to systems and are not organised on a disciplinary basis. A concern with problems thus requires an inter-disciplinary approach, and this is certainly a characteristic of these persons (farmers and advisors) in the fore-front of solving agricultural production problems.

The achievement of an inter-disciplinary approach in research is difficult because both the training of scientists, and the organisation of research, are largely along disciplinary lines. Groupings of specialists working together have some obvious advantages, but it can lead to a situation where communication of objectives and results is confined to persons in that group or discipline. As an hypothetical illustration, we might have scientists trained in agrostology, working together in an agrostology section, attending agrostology conferences, and publishing papers in Journals of Agrostology. The profession is thriving in terms of number of scientists and published papers, but on the farms, levels of pasture production are unchanged. This is an example of what Boulding (1956) has termed, "the spread of specialised deafness". Information that would contribute to the solution of a problem, is not being used because the would-be users are not aware of its existence and/or relevance.

MATHEMATICAL MODELS

One of the difficulties of adopting a systems approach in the past has been the lack of techniques to study complex systems as entities. The advent of computers has largely overcome this as it has opened up the potential for using complex mathematical models. Indeed most people have come to associate a systems approach with computer modelling.

A discussion of modelling is facilitated by the terminology developed by Innis (1972). He describes the benefits of models in terms of conceptual, developmental and output utility. Conceptual utility arises from the model providing a frame of reference on which to base one's thinking. Development utility is the usefulness of what is learnt as the model is developed, and output utility refers to the benefits derived from model documentation and output, by persons other than the modeller.

All persons use abstract models to study systems, in the form of mental models which provide the frame of reference for thinking about the system. However individuals vary in their ability to construct, manipulate and retain mental models of complex systems. Attempts to give these models verbal form tend to be characterised by communication difficulties. Everyone will have their own mental model of a grazed pasture system. The models will all be different, and it would be difficult if not impossible, to adequately describe them and resolve differences simply by using the verbal forms. Most conferences illustrate this point. Although mental models have high conceptual utility and may have developmental utility, their output utility is minimal.

A mathematical model requires the scientist to use precise quantitative statements rather than vague relationships. Thus a statement such as "... pasture growth rate is strongly related to temperature ..." implies a model but conveys practically no information about that model. Even standard linear regression models are of limited use for relationships which are obviously non-linear. Mathematical models tend to have the highest output utility because, if adequately documented, they can be examined, criticised, modified and used by other persons.

Mathematical models have been widely used by agronomists in other countries (e.g. Duncan *et al.* 1967; Holt *et al.*, 1975; de Wit *et al.*, 1971), although many of these are concerned with monocultures, which in some respects are easier to model than pastures. However, models of pasture growth have been developed (e.g. Brockington, 1970; Byrne and Tognetti, 1969). It is surprising the agronomists in New Zealand have not made greater use of mathematical models to study pasture grazing systems. By their very complexity, it is most unlikely that anyone has an adequate mental model of such systems and if they do, it is imperative that their model be put into a form that will maximise its output utility.

As a final comment on modelling, it should be noted that it too can become specialised along disciplinary lines with adverse features similar to those discussed earlier. It is not difficult to find examples where the original problems have been neglected in the pursuit of model aesthetics.

CONCLUSIONS

A systems approach does not provide automatic answers to questions of defining problems and allocating priorities. This can only be done by people but if they are utilising a systems approach it is likely that their information base and hence decisions, will be improved. No specific evidence has been provided that a systems approach will help in defining agronomic problems and setting research objectives. Convincing evidence will only come from agronomists themselves becoming involved and the challenge is for them to do so.

At present, the problem of achieving increased production from hill country is topical. The hill country pasture-animal system is very complex and there seems to be general agreement that more research is required to provide basic information. Decisions have to be made about how best to allocate limited research resources. My challenge is for the agronomy profession to seek to have some of these resources (3-4 scientists), devoted for a relatively short period of time (say 6 months), to the task of constructing a mathematical model of a grazed hill country pasture.

At the end of this period the model will not be "complete", in the sense that it accurately mimics reality and can be used to design and evaluate improved systems. However, I would confidently predict the following outcomes:

(i) The model documentation will provide a synthesis of current knowledge about hill country pasture production in a precise, quantitative form. As such it will become a basic reference point for all persons working in hill country research.

(ii) A list of agronomic problems and research objectives derived from an overall view of areas where lack of knowledge is limiting our understanding of the system.

(iii) The scientists involved in the exercise will have a much greater understanding of hill country production systems, and will be well placed to make informed decisions or recommendations about the best way to use available research resources.

(iv) The progress of New Zealand agriculture will not be noticably retarded by taking the scientists away from their normal research activities.

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