USE AND ABUSE OF CROP SIMULATION MODELS

Foreword
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The following four papers are an outgrowth from a special symposium held at the annual meetings of the American Society of Agronomy in Seattle on 14 Nov. 1994. The germ for the symposium was planted a year earlier, when I was looking for something in a file cabinet and happened across a copy of a paper that John Passioura wrote more than 20 years ago, entitled "Sense and Nonsense in Simulation Modeling." As I reread it, I wondered if his views had changed much in the interim, and how they might compare with those that others in the field might express if asked to address the same topic. This led to discussions at the 1993 meetings, where we decided to organize a symposium for the following year. John Norman (Soil Science, University of Wisconsin, Madison) helped me choose the speakers and agreed to referee the session, and I am most grateful for his assistance. The four speakers acquitted themselves so admirably that there were immediate suggestions, particularly from those in the back of the room, that the talks be published.

There are common themes to all four papers, but there are notable differences among them as well. Passioura draws a distinction between science and engineering approaches to modeling, then skewers them separately. He cautions that complex scientific models typically heap together multiple hypotheses regarding plant processes that as a group are untestable, while the simpler, engineering approaches are of little help in situations outside the range over which they were calibrated. Under prodding from reviewers, he has grudgingly identified a few instances where empirical engineering models have been useful in management situations, and where complex scientific models have provided some insight, at least to their developers.

Monteith's theme is balance: between measurement and modeling, between comprehensiveness and comprehension, and between components of crop models. In his view, science and crop modeling are too seldom compatible. Simple models are defensible if they are based on sound and robust principles, but often are so empirical that their scope is constrained to the range of their calibration data set. He does feel that crop modeling can be useful in delineating areas of imperfect understanding and in providing a means for interpreting and analyzing field observations. Their use in management should be explored, but carefully.

In Sinclair and Seligman's piece, the authors provide a historical perspective, drawing an analogy between the phylogeny of crop modeling and the ontogeny of a living organism. The field is currently in a maturation phase, in which the unbridled optimism of youth has been tempered by the realization that models cannot do all that had been promised. They note the faulty logic of many crop modeling efforts in assuming that science is best served by increasing reductionism and ever more complex models, but point to a number of successful applications of simpler, more robust models. They conclude that the value of crop modeling is primarily heuristic, but that it is substantial, both in the classroom and in the field.

Boote, Jones, and Pickering offer the most positive assessment of the state of crop modeling. They emphasize the importance of using a level of complexity appropriate to the problem at hand, and offer examples not only of specific useful applications of models to a wide range of problems, but also of cases where models have provided new insight into the physics and physiology of the processes represented. Their willingness to pay the page charges for the extensive list of object lessons is testimony to the strength of their conviction that crop modeling is already playing a valuable role, and that it is destined to increase.

The tension between science and engineering approaches, as Passioura describes them, permeates the debate over the appropriate use of crop models. It is evident that the applicability of models to answering questions within the classical framework of the scientific method is limited. However, in this era of ever-tightening budgets and emphasis on accountability (in the narrow, administrative sense), scientists more frequently find themselves asking not "Is it testable?", but rather "Is it fundable?", and not "What is the hypothesis?", but rather "What is the deliverable product?". Moreover, there are related disciplines, such as hydrology, pollutant transport, and meteorology, where model use is routine if not indispensable—and with increasing recognition that the role of plants cannot always be ignored.

If the entities that fund scientific research are clamoring for more accurate weather prediction or for estimates of the potential impact of global climate change, there is going to be increasing demand for numerical representation of plant growth and development. Even if this is done by scientists in our field, we may not be sure that it is science, but if it is done by others, we can be certain that it will not be. The challenge, indeed the obligation, of those who build models is to be honest about the limitations of their creations, and to conduct, or at least support, the basic research necessary to address these limitations.

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