ISHS Acta Horticulturae 456: II Modelling Plant Growth, Environmental Control and Farm Management in Protected Cultivation

PREFACE

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Abstract:
The First International Symposium in Models for Plant Growth, Environmental Control and Farm Management in Protected Cultivation was held in Hannover in 1988. Since then two workshops (Avignon 1991 and Alnarp 1995) in this field were organised. Since the symposium at Hannover, large progress has been made in the development, validation and application of crop models. So it was decided to organise the Second International Symposium on Models for Plant Growth, Environmental Control and Farm Management in Protected Cultivation. A central theme was the development and application of simulation models within the field of greenhouse cultivation. The aim was to stimulate communication and interaction among disciplines, within the context of sustainable, profitable and effective greenhouse production.

The increasing complexity of horticultural problems forces scientists in horticulture to modify their conception of the systems they work with and the methods for analysing and solving problems and designing solutions. Although cases do exist where only one small element represents a major bottleneck, modern horticultural production systems are, in general, characterised by intricate relationships and a high level of development, where improvements are only realised by sophisticated and well balanced modifications of the system and subsequent fine-tuning of the adapted production system. In addition problems encountered nowadays in the horticultural industry often result from interactions with the outside world: the role of the market, the consumers and environmental issues can no longer be ignored.

In this constellation methods to analyse and handle complex systems are indispensable. A system approach, based on models of various degrees of complexity and at various levels of integration, has proved its potential to deal with this kind of problems. Models of greenhouses, crops, pests, as well as tools based on such models enable scientists of different disciplines to join forces and to re-use knowledge generated within another context, for another crop, or another situation.

The systems approach adds a new dimension to horticultural science,

because it replaces in many cases empiricism with disciplinary knowledge. It does so by creating bridges between cell and crop physiologists, between horticulturists and crop physiologists and indeed joins expertise of such widely diverging disciplines like computer science, farm economics, control engineering, crop protection, botany, etc. Obviously, this approach represents a major development in the tradition of horticultural sciences, with great potentials in many areas, including education. I therefore strongly hope that this issue of Acta Horticulturae will find its way to many scientists working in greenhouse crop modelling, as well as to other scientists with a motivation to enter this field. I trust that the success of the symposium resulting from a happy combination of people, scientific relevance, skills, enthusiasm and luck, will be reflected in the papers collected in this volume. I am very grateful to all who contributed to it, and in particular to the editor, Dr. Leo Marcelis, and his referees. Their active involvement gave rise to an issue of high standards.

Hugo Challa
Convener

WELCOME ADDRESS

Chairman, ladies and gentlemen,

It is for me an hour to address your workshop on behalf of the graduate school Production Ecology. The graduate schoolwelcomes you all and that you will have a useful and fruitful workshop.

Agricultural Sciences have nowadays the double responsibility of explanatory insight oriented approaches and integrating synthesizing approaches. That double responsibility is very explicit in the horticultural sciences. The evolution of agricultural sciences from an empirical and skill oriented towadrs a science based and insight and understanding oriented scientific activity has accelerated during the last decades.

Reductionistic approaches have demonstrated how understanding may increase and how fast knowledge of the various basic processes may help to explain the functioning of living production systems.

The resulting tendency to emphasize lower levels of integration and to overemphasize the role of molecular sciences, biotechnology and experimental plant sciences can be seen at many places around the world. The enormous increase of funds for lower integration level research and the emphasis of that type ofactivity causes also an underestimation of the need for search on systems level. That movement was also visible within the agricultural sciences in the Netherlands and was one of the reasons for the creation of the graduate school of production ecology, some four years ago. There were more reasons.

1. The broadening ofaims of agriculture. Traditionally productivity increase and efficiency both in biotechnical andin economic terms were the major aim. Nowadays efficiency in environmental terms and limited use of energy are equally important aims. That means an increase in the efficiency of the use of water and various external inputs such as nutrients and energy. The fine tuning of crop protection measures which prevents the dependence and overuse of pesticides is equally important.
2. The possibilities for bridging gaps between various integration levels has increased through the development and application of various explanatory comprehensive models. These models integrate and synthesize process knowledge at various hierarchical levels in order to gain explanatory insight by heuristic approaches.
3. The tools to explore options for various management decisions; as well strategic decisions through for example multiple goal models as tactical or operational decisions through the use of summary models of elaborated explanatory models.

These three reasons in combination with broadly felt need for studies that use the detailed process knowledge in such a way that systems behaviour can be improved. That upscaling and aggregation and disaggregation is a science and skill in itself. You will discuss that during your conference. It forms also the basis of the graduate school.

The graduate school production ecology has a central mission - the development of production systems - that meet various societal aims and to explore options for agricultural production system and land use. In that way options for sustainability and sustainable productions systems are made operational. The school comprises 80 permanent staff (full professors, associate and assistant professor) that were screened and are continously screened on their qualitative and quantitative productivity. There are some 150 PhD students within the graduate schools. They are organized in 10 PhD groups that meet on a two weekly basis. The graduate school offers an intensive teaching program and hands a certificate ton students that fulfil the various requirements. Through this graduate training we aim at students that are capable to work in science and possess T-shaped skills.

The research in the graduate school is organized in 5 subprograms.

1. Growth determining factors
2. Growth-limiting factors
3. Growth-reducing factors
4. Methodology
5. Synthesis of ecologically balanced production systems

Ad 1. Growth determining factors

The ultimate goal of this subprogram is the optimal use of production-determining factors, given biophysical boundary conditions and societal objectives. Production-determining factors include plant and vegetation characteristics and their genetic basis, and environmental factors such as CO_2, radiation and temperature. Biophysical and societal conditions are translated into parameters that determine production in space and time. Potential, actual and optimal yields will diverge with the increasing importance of nature and landscape conservations, and ethical and environmental goals. The research covers a wide range of scales and levels of integration. Nevertheless, all activities converge towards the (biophysical) community and regional levels, irrespective of climate or geographical zone.

Ad 2. Growth-limiting factors

Crop plant growth and development can be limited by suboptimal conditions in the soil through: (1) Inadequate supply of nutrients and water or excessive amounts of plant-available toxic compounds and/or (2) physical conditions affecting root growth and functioning. Detailed knowledge of processes that regulate the bio-availability of nutrients and toxic elements in soils can be integrated to optimize crolp fertilization with maximum efficiency and minimal losses into the environment. Nitrogen transformation processes in soils, and methane production and consumption in soils are considered as functions of dynamic soil, water air and temperature regimes. To adequately express conditions in the field, attention is given to the physical properties of natural soil structures, including the effects of the soil fauna on physical soil quality parameters.

Ad 3. Growth-reducing factors

Fungi, insects, nematodes, viruses and weeds attack plants and are reducing potential yields by 40–50% world-wide, even under the present intensive applications of chemical pesticides. Studies concentrate on minimizing the growth reduction caused by biotic stress factors, in an ecologically safe and economic way. To manage pests and diseases, environmentally acceptable control methods will be developed which eventually result in sustainable crop management. Biotechnological methods are an indispensable tool in modern ecology for unravelling processes and understanding and manipulating relationships between plants, harmful organisms and natural enemies. Models are another instrument for the analysis of complex ecological systems. The practical spin-off will be biological and integrated pest management programmes, which fit well within integrated farming approaches.

Ad 4. Methodology

The goal of this subprogram is to focus on methodological aspects associated with optimal plant production in a sustainable, multi-functional agro-ecosystem. This subprogram is rather technical in nature and has a mathematical backbone; the use of existing computer technology and information science (GIS, knowledge systems and remote sensing) is crucial. The subprogram supports the other subprograms. Different methodological aspects of plant ecology are co-ordinated and integrated. The aim is an overview of all methodologies applied and applicable inn the context of this graduate school.

Ad 5. Synthesis of ecologically balanced production systems Increasing scarcity of land and other natural resources for food production, recreation and other land use demands ample attention be given to optimizing agricultural production systems in terms of the agricultural, economic and environmental points of view. The main objective of this subprogram is to produce a generic methodology to explore scenarios for productive cropping systems associated with a sustainable land use and natural resource management, and to establish location-specific options for their development. To do so, knowledge is integrated about processes and factors that determine, limit and reduce crop growth, and their impact on the environment. The options will have a strategic character, and include probabilities related to fluctuating environmental conditions. Research results will be applied to and tested in case studies covering different agro-ecological zones and protected cultivation.

You may imagine that much of your work in protected cultivations is with growth and yield defining factors. In protected cultivation you are in the position to manage and manipulate the environment. However, the requirements during growth and development may vary depending with the needs of the plant and the crop. Morphogenesis in combination with growth requires such a fine tuning. Less than 1 promille of agriculture takes place under optimal conditions. Only in some advanced agriculture areas and in protected cultivation these conditions may be fulfilled. It poses an enormous demand for knowledge and insight of these processes. It is striking to see that such knowledge and insight is still limited and that the contribution of whole plant physiologists in the field of form and function is so limited. To extend that knowledge, to identify high priority fields and to stimulate intensive collaboration is the major task of production ecology.

Your symposium is in the core of the field of our graduate school. It is for that reason that I am delighted that you are here. I wish you all a useful and fruitful conference.

Rudy Rabbinge