PREFACE

The growing demand for food and increasing scarcity of fertile land and other resources (water, energy, etc.) present multiple challenges to plant and crop scientists to meet the demands of future generations while protecting the environment and conserve biological diversity. Novel directions in linking basic plant sciences to crop and systems research are needed to meet the growing demand for food in a sustainable way. Crop performance can be changed by modifying genetic traits of the plant through plant breeding or changing the crop environment through agronomic management practices. To achieve that, systems analysis and modelling play an important role by integrating and evaluating new findings at the gene and plant level at higher scales of aggregation. Robust crop-physiological modelling can become an essential tool to use insights from functional genomics in explaining crop behaviour. Current crop models can predict crop performance over a range of environmental conditions. Recently QTL information has been incorporated into crop models, and this has proved the potential of narrowing genotype–phenotype gaps and of applying QTL-based models for the analysis of genotype-by-environment interactions. To make further progress, model structure must be upgraded to allow for more physiological feedback features. Model input parameters should be designed to be potentially grounded in gene-level understanding. Integration of crop modelling into genetic and genomic researches can enhance the future position of crop physiology in 'plant breeding by design' (Yin, X., Struik, P.C. and Kropff, M.J., 2004. Role of crop physiology in predicting gene-to-phenotype relationships. *Trends in Plant Science*, 9 (9), 426-432).

New tools derived from advances in molecular biology, genomics and plant physiology have yet not been widely adopted in plant breeding and integrated crop management because of inability to connect information at the gene level to the phenotype, crop and agro-ecosystem level. The complexity and need for integration can be illustrated by quotes of:

a. *Lloyd Evans*: "Crop yields are the integrated end-product of many processes being researched by reductionist scientists at various levels. For such research to be effectively used in agriculture there must be continuing and effective interactions between researchers at the various levels of complexity" (*The Journal of Agricultural Science*, 2005, 143 (1), 7-10).
b. *Matthew Reynolds and Norman Borlaug*: "In addition to genetic challenges of crop improvement, agriculturalists must also embrace the problems associated with a highly heterogeneous and unpredictable environment. Not only are new genetic tools becoming more accessible, but a new generation of quantitative tools is available to enable better definition of agro-ecosystems, of cultivar by environment interactions, and of socio-economic issues." (*The Journal of Agricultural Science*, 2006, 144 (2), 95-110).

The international Frontis Workshop "Gene–Plant–Crop Relations: Scale and

Complexity in Plant Systems Research", held at Wageningen, The Netherlands, 23-26 April 2006, aimed at presenting and discussing new directions to bridge knowledge from the gene to plant, crop and agro-ecosystem level and at solving problems in production ecology and resource use by identifying and applying new research tools. This workshop was attended by about 80 participants from 20 countries and comprised 9 keynote presentations, 12 invited oral presentations and four poster sessions. For each of the poster sessions the posters were evaluated by two senior scientists; based on the scores four young scientists received an award. Presentations and discussions during the workshop sought to identify the most promising opportunities in this emerging field, and also the more recalcitrant challenges.

Keynote and selected contributions to the workshop were the building material for the contents of this book. All papers have been reviewed by two international experts and the editors. The sections of the book cover the following themes:

- Genetics of plant performance; from molecular analysis to modelling
- Modelling genotype × environment interactions
- Genetics and physiology of crop adaptation
- Physiology and modelling of plant functioning and crop performance
- Diversity, resource use and crop performance
- Outlook and dialogue on future research.

The contents of most contributions combine the presentation of the state of the art in specific fields, based on a concise review of progress made and illustrated by results of ongoing research, and an outlook on future research.

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People make things work; the cooperation of participants and authors and the enthusiasm of the staff of the Group Crop and Weed Ecology (CWE) and of Frontis were vital for the success of a challenging scientific event and a high scientific quality. We hope that this book reflects the inspiring scientific atmosphere of the workshop and will give food for thoughts on new research directions in plant sciences.

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