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Editorial

Nowadays, greenhouse production must satisfy high standards of product quality (in terms of composition, mechanical properties, post-harvest behaviour, health value…) and environment protection (through the reduction of nutrient and pesticide release). Original sets of cultivation techniques such as climate control, fertigation and crop protection must be designed to reach these objectives. This special issue of *Agronomie* intends to present the most recent approaches of (i) the interactions between greenhouse crops and their environment in relation to the formation of product quality and the protection of the environment, and (ii) the design of management tools of the protected cultivation systems aimed at reducing their environmental impact and improving the quality of their products. Some new and interesting trends have been identified by the contributors of this issue. The research teams they belong to have had to renew their approaches to the greenhouse ecosystem [1] to face the environment and quality issues. The paradigms that were worked out when production and energy saving were the main objectives [2] are not fully adequate in the present context of protected cultivation. For example, if using the mean values of radiation and temperature inside a greenhouse was enough to calculate a thermal balance, it is not appropriate for understanding the dynamics of pests and diseases.

Claiming that the greenhouse environment is not homogeneous is certainly not original. What is new is to consider heterogeneity as an output variable that should be kept under control. What the growers sell is not an average plant or fruit but a set of plants or fruits that should all fit precise specifications. That is the case for the plant size and nitrate content of lettuce in the cropping systems studied by Marius Heinen and Stéphane de Tourdonnet and co-authors. Both groups of authors have shown that heterogeneity is structured by the cropping methods (e.g. soil compaction by tractor wheels, method and frequency of irrigation), which gives some clues to reducing it. Local accumulation or leaching of salts are also amplified by heterogeneity. In the aerial environment, the behaviour of pests and pathogens depends on the local microclimate they experience in general on the surface of organs. That is why Thomas Jewett and William Jarvis put the case for studying the microclimate in the boundary layer of leaves. What was not needed for an effective use of pesticides becomes compulsory to understand and master the processes involved in the development of pests and diseases and of the biological control agents that interact with them.

The physical characteristics of the protected cultivation systems in use or under development present other constraints. One is the inertia of the root substrates. Jacques Le Bot and co-authors provide clear experimental evidence of the ability of rockwool slabs and of some organs of tomato plants to deliver nitrogen to the growing organs for several days after stopping the N supply in fertigation, and maintain their rate of growth and development. Such a strong buffering effect makes the adequation of the water and nutrient supply to the variations in the crop demand difficult, as pointed out by Hans-Peter Kläring. Martine Dorais and co-authors, and Asher Bar Tal and co-authors demonstrate how a poor control of the salt concentration in the root environment may result in various disorders, in the formation of the tomato fruit and rose flower quality, respectively. Recirculation offers the opportunity to accelerate the turn-over of the nutrient solution in the root substrate by increasing the leaching fraction without any polluting consequence on the environment. Yet the price to pay is a higher potential for rapid spread of root diseases. That is why various methods of disinfection, reviewed by David Ehret and co-authors, have been worked out.

A closer control of the greenhouse ecosystems should be facilitated by the automatic retrieval of information from its physical and biological components. In a second paper, David Ehret and co-authors list several sensors that, once connected to the computer control system, would provide on-line information and enable rapid decision making. For designing environment-friendly strategies of fertigation, Hans-Peter Kläring analyses the potential of ion specific sensors. Another example is provided by Soraya Guichard and co-authors who mention the use of sets of displacement transducers for monitoring the water balance and the resulting quality of growing tomato fruits. Yet, because of the inertia of some components of the system, an effective feedback control may be not possible. That is why feed forward control based on predictive models is another active line of research. That is particularly true for the fertigation of both soilless and soil cultivation systems. In the former, Hans-Peter Kläring stresses the need for models to improve product quality in relation to the properties of the root environment. In the latter, Stéphane de Tourdonnet and co-authors use models as evaluation tools of the environmental impact of fertigation strategies. Interestingly, they prove that sophisticated models can be useful in poorly controlled plastic tunnels as well as in high-tech glasshouses.

Finally, several contributions present significant advances in the understanding of the formation of product quality in relation to the crop environment. Together, the two reviews signed by Martine Dorais and co-authors and Soraya Guichard and co-authors form a comprehensive overview of the influences of the shoot and root environments on the various components of the fruit quality. Noteworthy, these influences are often analysed via the fluxes of carbon, water and minerals in the plant and towards the fruit. Therefore, it can be expected that the present interest in the mechanisms of quality formation and their control will boost the evolution of crop models towards the merging of the classical growth models based on the carbon fluxes and of models of water and mineral fluxes in development [3 and companion papers].

The ten papers of this issue reveal that new state and flux variables of the greenhouse ecosystem are now subjects of active study, particularly those characterising the root environment, the quality of products and the behaviour of biotic agents. We hope readers will find in them material for identifying the novel concepts and methods suited to the present challenges of agriculture.

[1] Enoch Z., Stanhill A., Greenhouse Ecosystems, Elsevier, Amsterdam, 1999.

[2] Bakker J.C., Bot G.P.A., Challa H., Van de Braak, N.J., Greenhouse climate control, an integrated approach, Wageningen Pers, Wageningen, 1995.

[3] Gary C., Jones J.W., Tchamitchian M., Crop modelling in horticulture: state of the art, Sci. Hortic. 74 (1998) 3–20.

Christian Gary
INRA, Avignon