Complying with Society's Demands - Solving the Emission Problem Caused by Irrigation Surplus in Greenhouses

E. Beerling[a], W. Voogt, T. Vermeulen and W. Verkerke
Wageningen UR Greenhouse Horticulture
Violierenweg 1
2665 MV Bleiswijk
The Netherlands

M. Heinen
Wageningen UR Alterra
Droevendaalsesteeg 4
6708 PB Wageningen
The Netherlands

Keywords: emission, water, nutrients, pesticides, society, transition, innovation

Abstract

Irrigation surplus is a commonly used strategy in soil grown crops in greenhouses in the European Union. This leads to emissions of both nutrients and plant protection agents, resulting in problems with the quality of ground and surface water. New European regulations will be implemented, limiting the amount of nutrients and plant protection agents to be released in the environment. These developments pose a serious challenge – or threat – to commercial growers in Europe. We develop innovative solutions that aim at social, economic and environmental sustainable production systems. These solutions can only be implemented successfully when all stakeholders are involved in the process and show their commitment. An overview of our strategy, actions and projects is presented.

INTRODUCTION

For several decades research of Wageningen UR has dedicated considerable scientific effort to the study of plant nutrition and crop protection. After World War II, Western society simply asked for products, and our efforts contributed to an increase in both yield and product quality. We studied nutrient uptake of various greenhouse flower and food crops, learned about nutrient deficiencies, introduced substrates as a rooting medium for some crops, developed good agricultural practices for plant nutrition, improved yields, and gradually understood the trade-off between yield and quality in greenhouse production systems. Over the years many scientific and popular papers were published, which were recently summarized by Sonneveld and Voogt (2009). Also, crop protection systems were developed and refined over the years, resulting in biological pest control and integrated pest management (e.g. De Buck and Beerling, 2006; Van der Lans et al., 2008).

Over the recent years, society's demands are changing. People are increasingly aware of the impact that agricultural production systems have on the natural environment. More recently, European Union regulations such as the water framework directive (European Union, 2000) and nitrate directive (European Union, 1991) that aim at safe and good water quality were developed and imposed. As a result, local initiatives are now emerging in which new coalitions cooperate towards the common goal of sustainable production (e.g. Thoenes, 2009).

Especially soil grown greenhouse crops require high fertilisation rates. Over-irrigation is common practice to prevent any shortness for uptake at minimal costs. Also, it induces salinity stress for quality improvement and as a result, leaching of nutrients (N and P) occurs. Both nutrients and plant protection agents follow the water flow, and the reduction of waste water is becoming an issue in dense greenhouse areas like in the Netherlands. This waste water is discharged to municipal waste water systems and into surface water, containing high concentrations of both nutrients (Balthus and Volkers-Verboom, 2005; Wunderink, 1996; Boers, 1996) and residues of plant protection agents (Teunissen, 2005). Even in closed irrigation systems with cultivation on substrates, drain is sometimes inevitable. The regional collection and purification of drain water to

[a] Ellen.Beerling@wur.nl

irrigation water has been proposed (Van der Velde et al., 2008), but an alternative solution could be the redesign of production systems with no-emission as a primary design rule. This, however, requires a transition towards new sustainable agricultural production systems. Therefore, we started an integrated research project to develop such social, economic and environmental sustainable production systems. These systems can only be successfully implemented when all stakeholders are involved in the innovation process and show their commitment. We work on solutions by bringing different stakeholders together. An overview of our strategy, actions and projects is presented here. A comparison is made with transition processes in agriculture and with the current energy transition in the Dutch greenhouse industry.

TRANSITION PROCESSES IN AGRICULTURE

Transitions can be defined as planned structural societal changes towards sustainability (Poppe et al., 2009). Transition processes in agriculture towards sustainable production systems are well documented (Wijnands and Vogelezang, 2009; Vogelezang and Wijnands, 2009). Their strategy consists of six actions, viz., (1) Inspire stakeholders through identification of opportunities and shared future scenarios; (2) Identify trends and critical transition points with stakeholders; (3) Innovate through the generation of new insights and proof-of-principle projects; (4) Connect people by organizing workshops, innovation café's and coalitions for innovation; (5) Stimulate innovators through individual coaching and networks of early adopters, and finally (6) Broaden the initiatives by the construction of demonstrators, organizing excursions and sharing the knowledge in virtual and physical knowledge centers. A typical feature in the innovation process is the cooperation with stakeholders to identify trends and transition points in an "innovation agenda" (Fig. 1). After such a platform is created, specific research can be carried out. Through a process of analysis and design, 'innovation projects" with pioneering growers (Fig. 1, stars in the right hand arrow) can be set up. The "networks of early adopting growers" (Fig. 1, left hand arrow) may both contribute to and learn from these innovation projects. The successful elements from these innovation projects can be directly used by the participants at their own companies. Through the formation of networks of early adopting growers, experience and knowledge can be shared and spread. Gradually, early adopting growers may become pioneers themselves.

THE ENERGY TRANSITION

Over the recent years, a transition is taking place in the Dutch greenhouse industry from energy consuming towards energy production (Roza, 2006). This has resulted in a joint innovation agenda and research programme "Kas als Energiebron" (The Greenhouse as Energy Source) which generated enthusiasm und confidence among stakeholders, initiated numerous initiatives and created a vast body of new knowledge (see website Kas als Energiebron, 2009). It also lead to innovation projects with pioneering growers such as Greenport Glasshouse in Venlo (Verkerke and Vermeulen, 2008) and the Energy Producing Greenhouse in Bergerden (De Zwart et al., 2008). These innovation projects showed that a reduction of the use of fossil energy was really possible and also allowed growers to learn by doing, generating enthusiastic responses from stakeholders. Networks of early adopting growers, either national or local have played a role the transfer of knowledge to early adopting growers, stimulating them to use innovative technology (Verkerke, 2008). The elements of the innovation process from Figure 1, viz., "innovation agenda", "innovation projects" and "networks of early adopting growers" are thus clearly discernible in this energy transition. We participated and learned from this transition, and now try to set up a transition towards emission free greenhouses.

THE START OF AN EMISSION TRANSITION

With support by the System Innovation programme of the Dutch Ministry of Agriculture and SenterNovem, we started an integrated research project. One of our first actions was the organisation of a series of workshops with all relevant stakeholders to design emission free production systems. We do not aim at an incremental innovation but want to redesign the production system, starting from the prerequisite of emission free.

In the workshops we exchanged knowledge on the implementation of good and best practices and developed plans of requirement for emission-free cropping systems. We pictured a vision of "Emission-free Horticulture" and designed pathways to reach this vision. Subsequently we analysed the knowledge needed and identified knowledge gaps. Several case crops were used to guide the selection of proof-of-principle experiments towards applicable and relevant concepts. These proof-of-principle experiments are scheduled for this and the following year. The determinant factors in this process are the joint identification of motivations for change, bottlenecks and possible solutions, and, most important, the creation of mutual confidence among different actors. This confidence is a prerequisite for the future creation of an "innovation agenda" (Fig. 1). The next step could be a nation-wide broadening of the confidence with more stakeholders and national acceptance of the pathways recognized. We foresee that it will need more multi-stakeholder sessions to allow for the creation of an innovation agenda. When a pioneering grower decides to invest in one of the generated solutions of the proof-of principle experiments, we can start an innovation project (Fig. 1, right hand arrow).

We have also started "networks of early adopting growers" (Fig. 1, left hand arrow). In these networks we also search for congruent interests, resulting in common goals, but there is also room for the individual interests of the different partners. Such networks were established in the province of Limburg and in the Bommelerwaard polder. The participating growers meet on a regular base at their own companies, and discuss the different strategies used. Emission routes are mapped and quantities of emission are measured. Together, alternative strategies for good and best practices are constructed.

We use lysimeters in the commercial greenhouses of the early adopting growers, not only for measuring emission, but also to start a dialogue with growers. Lysimeters are widely used in scientific projects, but there are no ready-made concepts available to measure the emissions in commercial production companies. Our lysimeters are adapted for use in modern commercial greenhouses (Voogt et al., 2006) to monitor nutrient emissions in soil grown crops. In the course of our first experiments in commercial greenhouses, several technical bottlenecks appeared. The lysimeter conflicted with the practical soil tillage. We are now focusing on the solving of these practical problems. Simultaneously, a fundamental study of the behaviour of N and P in the soil is carried out to improve the robustness of the lysimeter. The effects of soil type, hydrology, mineralisation, denitrification and the relation with existing fertigation models are taken into account (Heinen, 2006).

DISCUSSION AND CONCLUSIONS

The scheme with two transition pathways from Wijnands and Vogelezang (2009) and its practical elaboration (Vogelezang and Wijnands, 2009) proved to be helpful in the understanding of the current energy transition and the planning of the new emission transition. Some elements of Figure 1 are discernible in the integrated research project on emission. Our efforts concentrate on the first four actions as mentioned by Vogelezang and Wijnands (2009) in this stage of the transition process. Of course there are clear differences between the two transitions. The energy transition has been going on for some years and has produced great enthusiasm among stakeholders, a massive body of knowledge and a considerable reduction of fossil fuel use, whereas the new emission transition has just started. Also, a possible reduction of fossil fuel use could be of direct economical advantage for growers, whereas a possible reduction of nutrient emission provides only slight direct economic advantage against increased risks due to changes in the production strategy. Nevertheless, our combined approach towards emission innovation projects, an innovation agenda and regional networks has started. Based on our knowledge and experience, we present a realistic approach for a transition that could meet the demands of modern European society. We are learning by doing, but also believe that this approach might offer opportunities in a European context as well.

Researchers interested in cooperation in this field are invited to contact us.

ACKNOWLEDGEMENTS

This research was funded by the Dutch Ministry of Agriculture. We thank Eric Poot (Wageningen UR Greenhouse Horticulture) for reading the manuscript.

Literature Cited

Balthus, C.A.M. and Volkers-Verboom, L.W. 2005. Onderzoek naar emissies van N en P vanuit de Glastuinbouw. RIZA Rapport 2005, 52p.

Boers, P.C.M. 1996. Nutrient emissions from agriculture in the Netherlands causes and remedies. p.183-189. Diffuse pollution '95. Proc. 2nd IAWQ International Specialized Conference and Symposium on Diffuse Pollution. Pergamon Press, Oxford.

De Buck, A.J. and Beerling, E.A.M. 2006. Implementation of biocontrol and IPM in Dutch horticulture. p.73-90. In: J. Eilenberg and H.M.T. Hokkanen (eds.), An ecological and societal approach to biological control. Springer, Dordrecht.

De Zwart, H.F., Van Noort, F. and Bakker, J.C. 2008. Energieprestatie en teeltkundige ervaringen in de energieproducerende kas. Wageningen UR Greenhouse Horticulture Report, December 2008.

European Union. 1991. Council directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC).

European Union. 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Heinen, M. 2006. Simplified denitrification models: overview and properties. Geoderma, 133(3-4):444-463.

Kas als Energiebron. 2009. www.kasalsenergiebron.nl

Poppe, K., Termeer, C. and Slingerland, M. (eds.) 2009. Transitions towards sustainable agriculture and food chains in peri-urban areas. Wageningen Academic Publishers, Wageningen.

Roza, C. 2006. Kas als energiebron - keerpunt en katalysator. InnovatieNetwerk / Stichting Innovatie Glastuinbouw, Utrecht / Bleiswijk.

Sonneveld, C. and Voogt, W. 2009. Plant nutrition of Greenhouse Crops. Springer, Dordrecht.

Thoenes, E. 2009. Telers Woudse Droogmakerij streven naar schone sloten. Vakblad Bloemisterij 35:18-19.

Van der Lans, C., Beerling, E.A.M. and Ramakers, P. 2008. Plant health in innovative growing systems. IOBC/wprs Bulletin 32:219-225.

Van der Velde, R.T., Voogt, W. and Pieckhart, P. 2008. Kasza: Design of a Closed Water System for the Greenhouse Horticulture. Water Science and Technology 58(3):713-725.

Verkerke, W. 2008. Door zo'n netwerk ben je echt met energiebesparing bezig. Syscope 16:8-9.

Verkerke, W. and Vermeulen, T. 2008. Grower delivers heat to external partners. Fruit & Veg Tech 8.3:8-9.

Vogelezang, J. and Wijnands, F. 2009. Methodisch werken aan systeeminnovaties. Syscope 22:2-9.

Voogt, W., Van Winkel, A. and Steinbuch, F. 2006. Evaluation of the Fertigation Model, a Decision Support System for Water and Nutrient Supply for Soil Grown Greenhouse Crops. Acta Hort. 718:531-538.

Wijnands, F. and Vogelezang. J. 2009. Two complementary transition pathways: supporting strategies for innovation towards sustainable development in Dutch agriculture. p.201-217. In: K. Poppe et al. (eds.), Transitions towards sustainable agriculture and food chains in peri-urban areas. Wageningen Academic Publishers, Wageningen.

Wunderink, H. 1996. De belasting van het Nederlandse oppervlaktewater met fosfaat en stikstof. Het Waterschap 81(9):304-311.

Figures

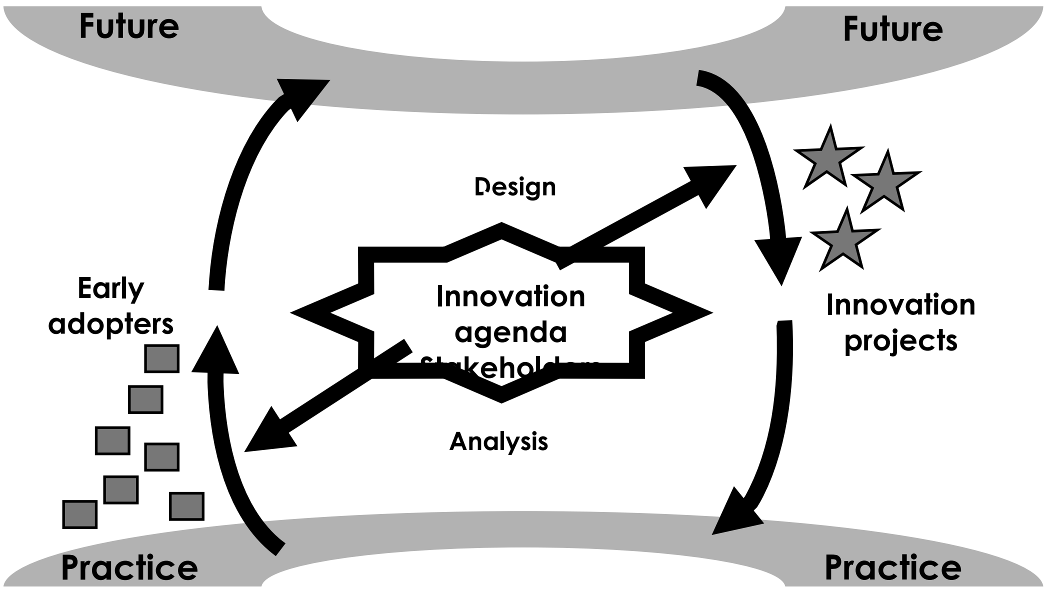

Fig. 1. Two transition pathways showing the innovation process. Modified from Wijnands and Vogelezang (2009).