

## Participative learning for the Future: using interactive farmer-research networks in the development of new plant production systems in The Netherlands

Hans Langeveld\* and Jet Proost\*\*

### Abstract

The paper analyses an ongoing process in a national project on the development of sustainable arable plant production systems in The Netherlands ('Farming with a Future' or Fwf in short). In the project, farmers, researchers and advisors co-operate to realise government's environmental objectives within a short period of time. Intensive fertilisation practices are a pressing problem in Dutch agriculture, especially for nitrogen application, per hectare of agricultural land the highest in Europe. Part of the project strategy was to incorporate learning into the change process. This was strived for by making specific adjustments in the project setup for the facilitation of more effective knowledge transfer, feedback and reflection. The paper discusses how this was done and with what effect. The structure of the regional networks fostered interaction between major stakeholders, creating the basis for learning in FwF. The choice to set up diverse, multi-disciplinary platforms for data exchange has contributed to the creation of effective learning conditions. This is also the case for the synchronous execution of three research programs, and certainly holds for the on-farm trials that have been held.

### Introduction

While coupling collaborative learning to processes of change seems to be accepted in agricultural projects in industrialised countries, it is difficult to assess whether this actually leads to improved project outcome. This paper analyses an ongoing process in a national project on the development of more sustainable plant production systems in arable farming in The Netherlands ('Farming with a Future' or Fwf in short). In the project, farmers, researchers and advisors strived for realisation of national environmental objectives in arable farming within a short period of time. Desired changes in farming were supported by formal research that was executed simultaneously within the project. Part of the project strategy was to incorporate learning into the change process, for which, at project inception, specific facilities in project structure were implemented. The structure included specific platforms for interaction between the various stakeholders, with most interaction between farmers, researchers and advisors occurring in networks that were especially created for the purpose.

Combining social and biophysical sciences, the authors participated actively in the project, covering among us all of its platforms. Reflecting on our experiences, we discovered that at some points unusual learning appeared to occur. As we were already aware of some unique features in the project structure, we then decided to check whether structure and learning were linked. The central question of this paper is therefore, whether the Fwf approach has led to enhanced learning and - if it did - whether this is related to project structure. From this, we try to draw generic conclusions for other projects. In doing so,

---

\* Plant Research International, Wageningen University and Research Centre, P.O. Box 14, 6700 AA Wageningen, The Netherlands.

\*\* Wageningen University, Social Sciences Group, Communication Science, Hollandseweg 1, 6706 KN, Wageningen, The Netherlands.

we like to challenge our audience to contribute to the basic methodological question of giving evidence that effective learning and capacity building is taking place in a setting like FwF, and how this contributes to the project outcome.

## Context

Agriculture in The Netherlands is characterised by intensive cultivation practices. Nitrogen surplus per hectare of agricultural land (262 kg of nitrogen/ha) is the highest in Europe, being more than four times as high as the average level for the EU-15. Because of this, Dutch agriculture is an important source of nutrient emissions. In 2000, agriculture caused 40% of all acidifying emissions and two thirds of the nutrient loads to land and water resources (RIVM, 2001). While this already was an improvement as compared to the situation in the 1990s, further action still is needed in both dairy and in arable farming, which contribute significantly to ammonia volatilisation, production of greenhouse gases (nitrous oxide) and nitrate leaching.

Dutch legislation on nutrient application is based on the MINeral Accounting System (MINAS) that was introduced in 1998. The major instrument chosen is the farm gate balance, forcing farmers to account for nitrogen and phosphorus flows (inputs, output and surpluses). In 2000, manure transfer contracts were introduced for farmers producing more manure than they are allowed to apply on their own fields. At the same time, several measures were taken in order to soften the effects of the hardship of tightening nutrient legislation: manure and pig production rights were purchased by government, which also offered favourable fiscal conditions and made extra investments in research and extension. In 2001, additional research funds were supplied to assist farmers to comply with the environmental legislation

### *Agricultural research*

Research and extension in The Netherlands in the past were organised along a classical model, following a line from fundamental to applied research into extension. After successful application for more than four decades, this model gradually became complemented by a more systems-oriented multidisciplinary approach. The first farm-scale systems-oriented research program was initiated in 1979 with the establishment of a research farm in Nagele in the new polders, involving generalists and - when necessary - specialists covering agronomic, edaphic, climatic, economic and social aspects of farming. As high costs related to this type of research did not allow for replicates, it was decided to replace this by on-farm research on so-called pilot farms (commercial farms linked to the project). The 'Nagele' research approach can be compared with the classical setup of Farming Systems Research and Development (FSR&D) which gained much support towards the end of the 1980's, focusing on the farm system as a whole, involving interdisciplinary research teams and working with iterative, dynamic research programs.

Inclusion of the 'Nagele' pilot farms facilitated real world testing of research results and provided feedback to researchers. In return, innovations developed by pilot farmers could be used in the steering of the experimental farm research. The network thus facilitated links between farmers and researchers, allowing more effective feedback and interaction, and, hence, reflection on the way of thinking and working that existed in either group before they were linked. Over the years, the 'Nagele' program developed into a research approach with combined experimental and pilot farm research (see for example Vereijken *et al.*, 1994). This approach starts with the definition of a set of quantified, prioritised objectives that are used to design and develop a farm system. The system then is implemented at the

experimental farm, after which it can be applied and adjusted by pilot farms, before finally being disseminated to other commercial farms. During the process, there is plenty interaction between and among researchers and farmers, involving – at some point - various stakeholders including cropping specialists, modellers, policy makers, pressure groups, advisors and communication specialists.

This approach was adopted by a group - comprising of members from strategic research, applied research and an NGO - that set up a farm for environmentally oriented systems research in dairy farming. The farm, 'De Marke', later became linked to a research project involving a group of pilot farmers called 'Cows and Opportunities'. While realisation of environmental and economic objectives dominated the discussions in the early years, two-way communication and interactive exchange of views and information gained in force over time. By doing so, researchers and farmers developed a structure that facilitates effective data exchange and discussions on agronomic and environmental objectives, economic consequences and research strategies (see e.g. Oenema et al., 2001).

### **'Farming with a future'**

Towards the end of the 1990s, experiences in dairy farming formed the basis for a similar project in arable farming, 'Farming with a future' (Fwf), which became operational in 2000. It combines systems and experimental research, involving experimental and pilot farms. The research nutrient management, nature development and reduced input of agro-chemicals, the main focus being on the impact of nutrient emissions on quality of groundwater and surface waters. Fwf includes arable, field vegetable, tree and bulb farming, each sector being represented by an experimental farm and a number (five to fourteen) pilot farms, thus linking four groups of internal stakeholders (farmers, advisory services, research and applied research) plus project management. Project objectives are twofold: (i) to design, implement and improve sustainable plant production systems, and (ii) to communicate results to farmers and other stakeholders in the agricultural sector and society (Booij *et al.*, 2001; Neeteson *et al.*, 2001a). During inception, a range of environmental and production objectives was formulated. Objectives for the pilot farms are predominantly based upon existing nutrient policies; objectives for experimental farms are more stringent.

### *Theories of learning*

Learning was incorporated in the project set up, as it is considered an essential means of change that can enhance both individual and collective action. We see learning as a process, occurring through interaction among stakeholders with different perceptions and knowledge (LEARN, 2003), originating from different domains, each bringing their own background and assumptions (Kouzes and Mico, 1979). The notion of learning is derived from social learning theories, which regard learning as a process of social change. As put by Weblert et al (1995), social learning occurs "when citizens become involved in working out a mutually acceptable solution to a problem that affects their community and their personal lives". As to how learning develops, Kolb's experiential learning cycle was adopted, identifying four stages: (i) concrete experience, (ii) reflexive observation, (iii) abstract conceptualisation and (iv) active experimentation (Kolb, 1984). Effective learning will however only take place if individuals or groups actively engage in each stage, using their experience to reach new insight (Woodhill and Robins, 1998), thus requiring stakeholders to take responsibility for discussing and exchanging experiences, formulating problems and showing willingness to discover how things work and can be improved (Ratering and Hafkamp, 2000).

Farmers do not change in isolation. A movement towards sustainable agriculture would also require a parallel movement from their networks (Nieuwenhuize, 2000). Thus, groups of farmers, and their networks, are approached in the project, while the same attitude (collective approach of groups of stakeholders, recognising the fact that learning is a social process which requires a number of subsequent steps that cannot be taken in isolation) is applied with respect to internal stakeholders. Only in this way, the development towards sustainable agriculture is realised through a process of “learning our way out” (Finger and Verlaan, 1995).

### *Facilitating learning*

Although the importance of learning was recognised from the beginning, the way how this was to be realised was not really clear. Making use of experiences in the development of combined experimental & pilot farm research projects (starting with the ‘Nagele’ farm and being fully realised in the ‘De Marke’/‘Cows and Opportunities’ combination), many steps were taken intuitively. Three factors have been of major importance. Given the pressing environmental problems, (i) it was decided to implement two research programs (systems and experimental research on experimental farms) and a research and extension program on pilot farms synchronously in stead of putting them in place after each other as often is done. Further, (ii) project structure was designed in such a way that interaction and feedback between different internal stakeholders (experimental researchers, applied researchers, advisors and farmers) was guaranteed. This was done, finally, (iii) making use of multi-stakeholder platforms. The three elements are discussed below in some more detail.

Ad (i) Recognising from the beginning that the project required a specific setting for communication between farmers, researchers and advisors, and that progress would be realised from complex change processes rather than uni-linear adoption processes, researchers that preliminary used to work in mono-disciplinary research now were to co-operate with other disciplines in a setting where research on experimental farms was executed simultaneously with systems research and guidance of pilot farms.

Ad (ii) and (iii) In regular research, interaction between the diverse internal stakeholders involved in Fwf would be extremely rare. Researchers would mostly discuss among themselves, and experimental and systems researchers would not meet on a regular basis, let alone experimental researchers and advisors or farmers. Although this is understandable, it leads to a situation where data and insights travel a long way before finally arriving at the farmers’ tables, while each time a domain is being crossed interaction is becoming harder. In Fwf, the number of interfaces between both institutional as well as disciplinary domains was decreased by bringing stakeholders together in a number of integrated platforms, including regional networks where farmers results were exchanged, reflected upon and suggestions made for the next research cycle. In the communication, practical knowledge is considered as important as formal (or academic) knowledge, while classical one-way knowledge transfer from research to farmers was set aside.

### *Project setup*

Covering five groups of internal stakeholders, active in experimental research, applied research and extension in four agricultural sectors distributed over five regions, designing project organisation for Fwf was not easy. As was discussed above, the basic work is done in seven regional networks, each consisting of 3 to 5 pilot farmers, 1-2 advisors, an experimental researcher and an applied researcher (Figure 1). The networks meet at least 8 to 10 times a year, while there is additional contact among

individuals (mostly advisors and farmers or advisors and researchers). Collective members of all regional networks meet once a year in a two-day session, while researchers and advisors also meet in 8 sessions of the so-called ‘project team’, which also includes the management. Major characteristics of the project platforms are given in Table 2.

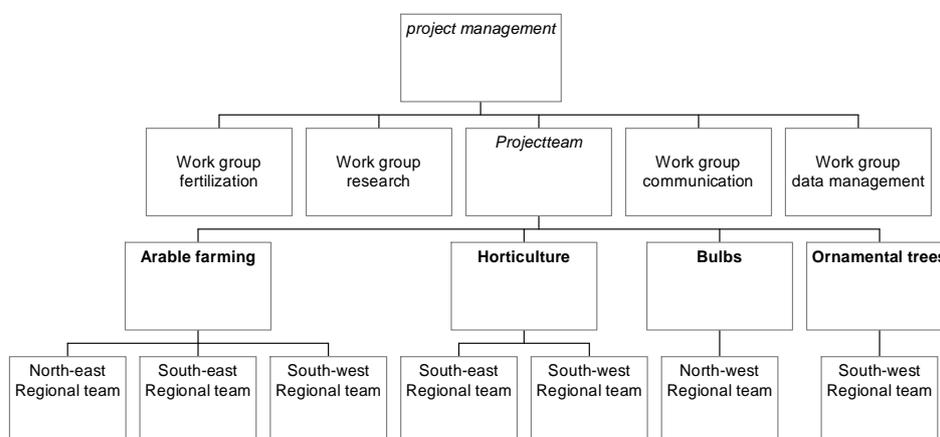


Figure 1. Structure of ‘Farming with a future’.

### Moments of learning

During the project, a broad variety of learning moments occurred. While it is beyond the scope of this paper to list them fully, a short overview is presented of relevant learning moments related to the first project objective (developing, applying and improving sustainable farming systems). Learning occurred in the definition of bottlenecks for the development of sustainable farming systems, the joint annual formulating and evaluation of farm plans for crop protection, nutrient and water management, etc., the bottom-up formulation of research questions, exchanges between regional networks, analysis and interpretation of data for environmental evaluation, reflecting on project strategy, giving feedback of learning points from regional level to management team, and holding sessions for monitoring and evaluation of project setup.

Table 2. Major platforms for exchange in the projects.

Platform	Objective	Meetings per year	Background of members	Major disciplines of members
<i>Regional network</i>	Advice farmers, discuss approach; exchange farm performance and impact on environment	8 – 10	Farmers (3-5), applied research (1), advice (1), research (1)	Agronomy, extension science
<i>‘Projectteam’</i>	Exchange experiences between regional networks; discuss project progress in relation to objectives	8	Applied research (4), advice (10), research (5)	Agronomy, extension science
<i>Two day conference</i>	Discuss project progress; exchange information; improve motivation	1	Farmers (33), applied research (5), advice (10), research (5)	Agronomy, extension science
<i>Working groups</i>	Discuss issues of communication, registration & analysis, research and fertilisation	3 – 4	Applied research (4), advice (2), research (8)	Agronomy, extension science, soil science, modelling
<i>Evaluation meetings for experimental farms</i>	Evaluate results experimental farms and impact on environment; discuss adjustments to be chosen	1	Applied research (6), advice (1), research (6)	Agronomy, extension science, soil science, modelling

## Results

Farmers showed large differences in the way they accepted and adopted alternative fertilisation practices. Most, but not all, farmers made considerable improvements in nutrient management over the three years the project now has run. Progress was often impressive during the first year, showing a decreasing speed thereafter. Large differences were also found with respect to crops where progress was made, as well as types of methodologies that were adopted. Most commonly applied techniques include the reduction of fertiliser application levels (getting in line with recommendations), correcting applications for mineralisation (i.e. indigenous soil fertility), and splitting fertiliser applications (not giving the entire load at once and thus being able to adjust the application rate during the season to crops requirements). Less frequently applied techniques include cultivation of 'catch crops' (grown after harvest of commercial crops to 'catch' available nutrients, in order to prevent them to be lost to the groundwater), application of slow release fertilisers (being less sensitive to leaching), changing manure application (applying treated manure with lower nitrogen levels or applying manure in spring in stead of autumn) and application of alternative sources of organic material (i.e. containing less nitrogen).

### *Adoption*

It is difficult to assess why some practices are adopted and others are not, or why a given farmer is adopting a given technique. Clearly, farmers only adopt something they understand and feel confident that no unreasonable risks are taken, but considerable differences were found as to what risks individual farmers find acceptable. Such differences were, rather surprisingly, also found among researchers and advisors. Further, it was clear that the decision to adopt or reject an alternative depends on the outcome of a more or less systemic evaluation of the innovation. If necessary, farmers did not hesitate to ask for additional information. Advisors and researchers formulated similar requests. Such requests generally could be rewarded, partly because a team of specialists was already involved in the experimental research of the project. In a few cases, Fwf specialists assisted in passing through requests to other specialists. The fact that specialist information was so easily accessible was highly appreciated and the number of request increased by the year whereby the experience of asking questions and receiving proper answers clearly helped to create a feeling of trust between the major internal stakeholders.

### *Learning*

Regarding the way in which enhanced learning did or did not occur, we first report some general results, after which the main features of the Fwf learning strategy are explored in two cases (one on crop protection and one on fertilisation), to see if evidence can be found that enhanced learning indeed took place and - if it did - if these features indeed were significant.

The structure of the regional networks fostered interaction between major stakeholders, creating the basis for learning in FwF. Because of the intensive interaction major stakeholders were forced into reflexive practice. In building a joint frame of reference team members encountered two types of tension which they had to overcome. Different disciplines, originating from different (institutional) backgrounds. Researchers had to explicit their views on important (technical) issues such as nitrogen leaching. Research plans were made collectively, both for research activities and for annual farm plans. Researchers had to actively step into farming praxis. It was further remarkable how project setup, with intensive and frequent interaction between researchers and advisors, generally not meeting each other very often in a setting like this, and coming from different institutions, forced them to reconsider each others role and therefore also the general view of each institution involved. This was not only useful in

communication related to the project; it also led to a relaxation of frictions that existed prior to the start of the project.

An interesting side effect occurred on the level of participation in decision making. In the beginning, coordinating and decision making was mostly done centrally by the management team. While developing dynamics during the project, however, researchers and advisors in regional networks asked for more room to manoeuvre. The management team, focussing mostly on progress in terms of environmental objectives and general project performance, needed some time to acknowledge that a more decentralised approach could provide regional network performance. Networks were given budgets for regional activities. Regional networks also claimed more time for exchange within and between teams during meetings of the Project team.

### *Cases*

The setting of this paper does not allow for a detailed evaluation of the potential techniques that were suggested to the farmers. It is of interest however, to mention two cases, showing how farmers evaluate alternatives in a systemic way, and how the project structure, especially the relatively large number of disciplines included in the project and the different platforms for exchange of information and/or views have played a role. In each case stakeholders became aware of gaining new insight. In Annex 1 we describe two significant cases. In the following we discuss the learning results in both cases.

In the case of the fertiliser strategy three research cycles were implemented simultaneously: research on pilot farms, and systems and experimental research on experimental farms. In the classical set up these research cycles would take place one after the other, independently, and only when conclusions were thoroughly grounded in repeated trials and tested. The insight that mineralisation appeared to be higher than expected was effectively shared by all stakeholders and led to adjustment of fertiliser practices and research in all three programs. From the start, all stakeholders were represented in diverse platforms, at all times including representatives of different kinds of experimental research, applied systems research and the advisory service. This led to the emergence of networks for effective data exchange.

In the case of the CropScan, FwF pilot farms successfully asked to be included in a testing program on CropScan application in leek, following an effective lobby starting in regional networks but soon including the 'project team' and reaching the management. It was further decided to compare this method to two alternative methods of analysis (mineral soil nitrogen and petioles). In a classical research setup this analysis would have been implemented on experimental farms. Under FwF, simultaneous field windows were designed at the pilot farms.

### **Discussion and conclusions**

The challenge of this paper is to prove that the chosen approach, including participative learning and trying to realise a structure to facilitate better learning, has been successful. While this is not easy, a number of indications show that pilot farmers, researchers and advisors effectively could exchange data and insights, reflect and give feedback, activities that helped them to select those techniques that potentially contribute most to their objectives. This is demonstrated by the cases discussed in Annex 1, and the quotes that are presented in Annex 2. We realise that the amount of evidence included in the paper is limited, but it is beyond the scope of the paper to go into more detail.

As to the question, to what extent enhanced learning is related to the project structure, this is even more difficult to answer. With hindsight, one might say that the choice to set up diverse, multi-disciplinary platforms for data exchange has contributed to the creation of effective learning conditions. This is also the case for the synchronous execution of three research programs, and certainly holds for the on-farm trials that have been held. As was stated before, most of these decisions were taken more or less intuitively and by no means at all times with the intention to improve learning conditions per se. It does however appear that, given the acknowledgement of the seriousness of environmental problems and experience in dairy farming research prior to the start of the project, sufficient elements were available for effective project setup. This paper has tried to analyse part of this in a systematic way, focussing on project organisation and learning conditions. It can be concluded that elements of the approach are no doubt also applicable elsewhere. One might consider, for example, the synchronous execution of different research programs, assuring data exchange in multi-stakeholder platforms and, preferably, a combined management. Further, setup of mixed, integrated platforms for data exchange and discussion certainly seems to be favouring learning conditions.

A last word, finally, on our co-operation. During the writing of this paper, we have reflected not only on the process as a whole, or the role of research, but also on our intentions when we first became involved in the project. Writing this paper therefore helped us to analyse the way in which conditions for learning were shaped, and to what effect, but also to decypher the way in which our own day-to-day decisions played a role in this. Although sometimes we seemed to speak very different languages, it helped us to reflect on ways to improve conditions in activities that are to come.

Concluding, Fwf has facilitated learning and probably more learning than could be expected. This was not always done intentionally; sometimes conditions for learning were created unintentionally. Nor did creating good learning facilities always play a role in day-to-day decision making. Creating learning facilities was, however, always related to project setup, elements of which also seem applicable in other projects under different conditions.

## References

- Booij, R., Van Dijk, W., Smit, B., Wijnands, F., Langeveld, H., de Haan, J., Pronk, A., Schröder, J., Proost, J., Brinks, H., Dekker & P., Ehlert, P., (2001). Detaillering projectplan 'Telen met toekomst'. Publicatie no. 3, Telen met toekomst (in Dutch). Applied Plant Research, Lelystad.
- Finger, M. and Verlaan, P. (1995). Learning our way out: a conceptual framework for social-environmental learning. *World Development*, 23, 505-513.
- Ison, R., High, C., Blackmore, C., Cerf, M. (2000). Theoretical frameworks for learning based approaches to change in industrialized country agricultures. In: Cow up a tree. Knowing and Learning for Change in Agriculture, Case studies from Industrialized countries. Cerf, M., Gibbon, D., Hubert, B., Ison, R., Jiggins, J., Paine, M., Proost, J., Röling, N. (eds.). INRA Paris.
- Kolb, D. (1984). *Experiential Learning*. Prentice-Hall, New Jersey.
- Kouzes, J.M. and Mico, P.R. (1979) Domain theory: an introduction to organizational behavior in human service organizations. In: *Journal of applied behavioral science*, vol. 15, no. 4, pp. 449-469.
- LEARNgroup (2003). *Learning. Workshopreport workpackage 3, LEARNing in European Agricultural and Rural Networks: institutions, networks and Governance*. Kaap Doorn, the Netherlands, 28 June – 1 July 2003.
- Neeteson, J., Booij, R., Van Dijk, W., De Haan, J., Pronk, A., Brinks, H., Dekker, P. & Langeveld, H., (2001). Projectplan 'Telen met toekomst'. Publicatie no. 2, Telen met toekomst (in Dutch). Praktijkonderzoek voor Plant en Omgeving, Lelystad.

Nieuwenhuize, W., Proost, J., Wijnands, F. (2000). Geïntegreerde akkerbouw, een gezonde toekomst voor sector en milieu. (in Dutch) Wageningen University and Applied Plant Research, Lelystad.

Oenema, J., Koskamp, G.J. and Galama, P.J., (2001). Guiding commercial pilot farms to bridge the gap between experimental and commercial dairy farms; the project 'Cows and Opportunities'. *Netherlands Journal of Agricultural Science* 49, 277-296.

Ratering, D. and Hafkamp, K. (2000) Zelfsturend Leren. Begeleiden van ervaringsgericht leren in organisaties. Academic Service, Schoonhoven.

RIVM, 2001. Nationale Milieubalans. National Centre for Health and Environmental Research, Bilthoven.

Vereijken, P.H., Wijnands, F., Stol, W., Visser, R., (1994). Designing Prototypes. Progress reports of Research Network on Integrated and Ecological Arable Farming Systems for EU and associated countries (Concerted Action AIR3 – CT920755). DLO Institute for Agrobiological Sciences and Soil Fertility (AB-DLO), Wageningen.

Webler, T., Kastenholz H., Renn, O. (1995). Public participation in impact assessment: a social learning perspective. *Environmental Impact Assessment Review*. 15, 443-463.

Woodhill, J. and Robins, L. (1998) Participatory evaluation, for landcare and catchment groups. A guide for facilitators. Australia.

## Acknowledgements

'Farming with a future' is a collaborative project by Applied Plant Research, Plant Research International (both part of Wageningen University and Research Centre) and DLV Advisory Group, and is supported by the Ministry of Agriculture, Nature and Food Quality and the Ministry of Housing, Spatial Planning and the Environment. The authors are indebted to the pilot farmers for their willingness to share their views and data, and to all researchers and advisors that at one point participated in the project.

## **ANNEX 1 Examples where intensive data exchange enhanced project performance**

### **▪ Generating a fertiliser strategy considering mineralisation**

Regional networks designed fertilisation strategies for each pilot farm at the beginning of the project. Input was provided by farmers and researchers, basing themselves on results of experimental research. Network members annually discussed farmers' performance over the previous year, after which farmers made plans for the new year. These plans were evaluated in the network, whereby researchers and advisors could do suggestions to farmers, making sure that that partial solutions which would be beneficial at one point but detrimental at another could be avoided. If necessary, specialists were invited to contribute to the discussion or provide information.

General issues regarding nutrient management were discussed by a working group. Findings were reported to the projectteam and – through researchers and advisors – communicated to farmers. Results from experimental farms were presented to the projectteam, which become the central focus of data exchange, discussion and feedback. Meetings became an effective way to be informed on research, while ideas for new strategies in nutrient management could be adopted. The fact that all non-farmer members of the regional networks were attending these meetings assured proper exchange of information to and from farmers. It was through such discussions that awareness was raised to the role of nitrogen release from mineralisation of organic material. Experimental results showed that the release exceeded expectations; realisation of environmental objectives required considering release more explicitly. This was discussed in the working group and presented to the projectteam. Researchers introduced participatory on-farm research for on-farm monitoring of nitrogen release on less intensively fertilised potato plots. Results astonished farmers, advisors and researchers alike, which strengthened links between the stakeholders, but especially between farmers and researchers.

### **▪ CropScan**

Reduction of nitrogen fertiliser application, the most common strategy to limit nitrogen losses, has important advances; it is economically potentially profitable and links well with agronomic advice. In many cases, fertiliser application is split into a starter base, followed by additional applications over the season. There are several methods to quantify the additional applications. The most commonly applied method is a destructive analysis of leaf petioles. Petioles are sent to a laboratory, which provides a fertilisation advice. Evidently, analysis and advice have to be paid for. A less commonly applied method is based on a non-destructive leaf canopy reflection measurement. This technique, referred to as CropScan, was available at the start of the project, being provided by a research institute involved in Fwf and some laboratories. CropScan requires technicians to operate the equipment and to calculate fertilisation advice. After the second year, it was decided to test the different methods for calculation of additional applications.

At the beginning of the project, CropScan application was restricted to potato. During the project, however, application became possible for leeks. Technicians of the research institute tested CropScan outside of the project, but pilot farmers explicitly requested CropScan testing to be extended to their crops, which was done in the next year. Communication on the extension proved to be fairly simple, as the pilot farmers request could be discussed with project management by non-farmer network members. We are convinced, therefore, that the networks involved contributed significantly to the extension.

## ANNEX 2 Boxes with learning experiences from various stakeholders

(strategic) research: “Nutrient management is complex. On-farm trials showed that a considerable amount of nitrogen is released by mineralisation. Using Nitrogen windows and CropScan made farmers aware of this invisible part of nutrient management. But also for us the effect of mineralisation was an important lesson which we learned through on-farm trials.”

Advisor: “Participating brings me closer to information on new developments in research. Before, it took such information long to get through to us. Research at experimental farms showed for instance how to grow cover crops under avenue trees. The experimental farm is not an exact replica of practice, but nevertheless the results give us food for thought in our discussions.”

Farmer: “Exchange meetings have added value, allowing me to compare results with colleagues, and exchanging ideas and experiences. Colleagues tell their own stories, providing background information at parcel level. I am not keen to adopt new ideas straight from the experimental farm; I like to hear a colleague’s view - a view from someone who tested it in practice, our practice - first. In that way I learned a lot about MLHD and the use of the CropScan.”

(applied) research: “Mutual exchange between researchers and practioners proved to be very useful. Through intensive collaboration we (researchers) gained more insight into bottle necks on the farms. Through close monitoring we gained more insight in the nitrogen dynamics in the soil and there fore we can provide tailormade fertilisation advices to the farmers. In our team a very positive collaboration generated openness to one another and through mutual respect we all made steps forward.”

