Organic Knowledge Network Arable
OK-Net Arable

Description of farmer innovation groups

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1 Executive summary

This report has been produced as part of the Organic Knowledge Network Arable (OK-Net Arable) project by members of Work Package 2 which adopts an interactive multi-actor approach, bringing practitioners from regional innovation groups together with advisers and scientists. This work package is responsible for facilitating testing of practical and educational materials with farmer innovation groups. The aim of this report is to provide a description of the farmer innovation groups involved with the project.

In order to gather information about the groups a common data collection framework was developed. This framework was used to collect information about the structure of the farmer innovation groups, the agronomic context of the groups, existing knowledge and skills, main challenges faced as well as potential solutions and potential tools to address these challenges

The data collection exercise has resulted in a description of the 14 farmer groups involved in the project, located in 10 countries. The groups have similarities in that they have mostly been established with an arable focus and have connections to research institutes. All groups have been established relatively recently, between 2010 and 2015. Members are a mix of new entrants and experienced organic farmers, most groups include farmers who have farmed organically for over 10 years. The members range in age from 20 to 70 years old, but most group members are over 30 years of age, and are predominantly male.

The farmer innovation groups represent a range of farm types including cereal producers, organic mixed farms, including livestock and field vegetables (e.g. potatoes, cabbage, leeks etc.), horticultural farms as well as stockless arable cropping systems. In terms of typical crops grown, most groups appear to be focused on cereal crops, which is to be expected given the focus of the project.

The report outlines some common challenges identified by the groups, namely: weed management, soil fertility, and pest and disease control. Other challenges were also mentioned, including: lack of knowledge and research, nitrogen management, nutrient cycling, challenges with grass and clover rotations, soil water content, cultivation issues, climatic changes, seeds and the availability of organic varieties

Recommendations for the project going forward include identifying practical best practice examples, ensuring that information can be found easily and consumed quickly, identifying context specific information, and provision of reliable information from trusted sources. Important areas include responding to farmer priority challenges in terms of the tools that the project tests, linking farmer perspectives with researcher knowledge and recommendations, and developing easy-to-use methods for online farmer-to-farmer knowledge sharing.

2 Introduction

The aim of the OK-Net Arable project is to improve the exchange of innovative and traditional knowledge among farmers, farm advisers and scientists to increase productivity and quality in organic arable cropping throughout Europe, and to improve their environmental performance, in order to satisfy citizens and consumer demand.

The project has three specific objectives: 1) to create a European network of well-functioning organic arable farmer innovation groups representing the best examples of co-innovation by farmers and researchers; 2) to digest and synthesize scientific and practical knowledge about organic arable farming to identify best practices (the project will develop and test innovative practical and educational material based on this information); 3) to create a European platform for knowledge exchange focusing specifically on organic arable drawing on experiences from diverse contexts. The project consists of 4 work packages. As part of the project, Work Package 2 has formed an international network of regional organic arable farmer innovation groups in order to better understand the success factors that make end-user and education materials effective and useful in a practical context. This will enable the project to identify solutions that farmers, agricultural advisers and researchers have developed that could be tested in other regions and countries.

In order to facilitate effective knowledge exchange between farmers and advisers in diverse countries, it is necessary to better understand these farmer innovation groups and the contexts in which they operate. This includes: the relationship between the groups and with ‘practice partners’ who represent research institutes and organic sector organisations who provide advisory services for producers; the aims and working arrangements of these groups, their members and the agronomic and climatic contexts within which the groups operate. In order to identify the factors that constrain organic arable production it is also useful to gain an understanding of what farmers perceive to be their main challenges and use these to identify farmer information needs. As well as identifying challenges it is also useful to assess farmer ideas for solutions as this enables us to understand their current knowledge base and to identify where there are gaps.

Section 4 provides a description of each of the practice partners who are responsible for coordinating the farmer innovation groups. Section 5 gives a brief description of each of the farmer groups involved in the project (with summaries of their aims, the number of members including gender, the age of members, the farming systems and farm size, crops grown, climatic context and main production challenges). Section 6 provides a comparison of the key characteristics of the groups including the aims and modes of operation and the members. Section 7 gives a summary of the agronomic and climatic context of the groups including the farming systems, main crops grown and yields achieved, soils and rotations, main challenges identified and solutions proposed. Section 8 compares issues identified by the farmer innovation groups with the ‘State-of-the-art research results and best practices’ report compiled by research partners involved in the OK-Net Arable project. Section 9 gives a brief overview of farmer’s current access to information. Section 10 indicates potential of the groups for innovation and section 11 summarises with some concluding remarks for the next stages of the project.

3 Methods

At the start of the project a data collection framework was designed to gather information about the farming contexts of the innovation groups, the challenges they face, their ideas for solutions and knowledge exchange tools that are currently utilised. The ‘practice partners’ involved with the project (Bioforum Vlaanderen/INAGRO, Bionet, Bioselena, Con Marche Bio, Estonian Organic Farming Foundation, ITAB, ÖMKI, SEGES, VÖP and ORC) identified arable farmer groups that they wanted to work with during the project in order to identify and test innovative practical and advisory materials (see description of WP2 for more details). Information about these groups, and their farming contexts, was collected using the data collection framework.

The data collection process was divided into three parts:

1. Part 1 focuses on information about the practice partners, the farmer group, farming context of the group members, the knowledge sharing infrastructure and group dynamics. Most of this information was collected by the practice partners themselves, with some input from the groups when necessary.
2. Part 2 consists of participatory exercises to obtain views from the farmer group about challenges and solutions, innovations and tools for knowledge exchange. These exercises were facilitated by the practice partners with the selected farmer groups and the results were documented.
3. Part 3 contains a survey about the channels that individual farmers currently use to access information. These questions were circulated to individual farmers within the groups to complete themselves either online via SurveyMonkey or on paper.

The framework was used to collect information in a common format across the respective countries. Overall there were good responses from the groups to Parts 1 but with some variation in the level of detail provided. Responses were less detailed regarding questions about knowledge exchange and innovation. The participatory exercises of Part 2 about challenges and solutions were reportedly popular with many of the groups because they gave a chance for group members to play an active role in discussions, useful and detailed information was gathered as a result.

The subsequent data was compiled and analysed in order to identify similarities and differences between the groups. Additional information was collected from partners where necessary. The resulting report was circulated for comment before being finalised. Responses to Part 3 of the data collection process are included in a separate report ‘D3.2: Identify best methods for learning and knowledge exchange’.

4 Description of the practice partners

OK-Net Arable works with ten 'practice partners' who are engaged in research and innovation activities in various parts of Europe. Each of the partners works closely with established groups of organic arable farmers or farmer associations in various capacities. As such the partners act as group coordinators and as the main contact point for the project. The 'practice partner' organisations represent a variety of institutional types including non-profit and non-governmental organisations, research institutes, agricultural advisory services and agricultural cooperatives. The practice partners and their relationship with the farmer groups are outlined briefly below.

1. **Bionet Austria** is an educational research project that was founded by advisers of the chambers of agriculture and researchers from FiBL Austria in 2005, to adapt (inter)national research results to Austrian conditions and to evaluate farmers' existing knowledge. Bionet established different working groups to facilitate two-way exchange of knowledge between farmers, advisers and researchers. About 70 farms participate actively in the project. The farms are located in all regions of Austria with arable cropping and vegetable farming. Problems affecting arable farming are discussed, and topics and farms are selected for field trials. The results of the field trials are promoted via a website, leaflets and seminars. Two regional groups are actively participating in OK-Net Arable.

2. **BioForum Flanders** is a non-profit sector organisation for organic farming and food. The organisation works across the value chain with producers, processors and consumers. BioForum Flanders started a farmers' network for arable crops and vegetables in 2008. BioForum is the facilitator of the networks and the INAGRO Department of Organic Crop Production acts as the research/dissemination partner. The network aims to optimise production practices, farm management and product quality as well as to improve sales. The network facilitates knowledge exchange between farmers, researchers and other actors in the value chain. The farmers take the lead in these networks. The cropping network is participating in OK-Net Arable.

3. **Bioselena Foundation for Organic Agriculture in Bulgaria** is a Bulgarian non-governmental organisation (NGO). The main aim of Bioselena is to develop and support sustainable and organic agriculture, biodiversity preservation and environmental protection. Bioselena established a network of farmers, researchers and advisers in 2014 with the aim of sharing existing information, best practices and innovative methods to solve the main problems of organic arable production. One group of arable farmers participates in the project.

4. **ConMarcheBio in Italy** is a consortium established in 2010 consisting of five organic farmer cooperatives. ConMarcheBio represents the majority of organic farmers in the Marche region and covers the whole durum wheat value chain, from wheat production to pasta making. The aim of the organisation is to improve and promote the production of several organic cereals supporting a return to greater diversity through the use of ancient grains. A smaller group of farmers was brought together to work on the project

5. **Institute Technique de l'Agriculture Biologique** (**ITAB**)in France is the agricultural technical institute dedicated to research and experimentation in organic farming. The organisation is

dedicated to the national coordination of research and experiments. The institute brings together field experts, researchers and professionals to produce technical information about organic production methods that are useful to both organic and conventional farmers. ITAB established the RotAB network and has links with the BASE farmer network which both participate in the OK-Net Arable project. ITAB proposed to involve the BASE-ABC group in the OK-Net Arable project because they are very innovative, willing to exchange knowledge and complement the experience of the RotAB network.

6. The **Estonian Organic Farming Federation (EOFF)** is an NGO that aims to support the development of organic farming, from primary production to processing and marketing. It provides information, training, policy development and is engaged in research and sector development projects both at national and international level. The main target groups are actors in the organic sector (farmers, processors, caterers, traders etc.) and the wider public. By organising seminars, workshops, field days, study trips the groups aim to provide better access to knowledge to the organic farmers in Estonia. The group working on cropping systems with OK-Net Arable was established in 2015.

7. The **Research Institute of Organic Agriculture (ÖMKi) in Hungary** works to enhance research and development in organic agriculture and food production. The organisation has developed an organic arable farming network to engage farmers in participatory practical research to increase their productivity and competitiveness. The network tests the performance of types, varieties, preparations, methods, and seed mixes under a diversity of practical conditions. Participating farmers learn from these experiences, gaining knowledge and feedback that is directly relevant to their growing conditions and production methods. The network contributes to a broader understanding of organic production in Hungary and indicates solutions that can help to improve the sector. The network also organises meetings and produces online open access publications to publicise the research results. The group working with OK- Net Arable was initiated to address a specific crop production challenge: variety testing.

8. The **Knowledge Centre Denmark (SEGES)** is a private non-profit demonstration and research organisation owned by the Danish Agriculture and Food Council. The organisation has established a network of arable farmers which aims to improve yields and reduce dependency on conventional animal manure. The network uses the farmer field school approach where farmers advise each other and local advisers act as facilitators. Both farmers and facilitators have received up-to-date scientific information on topics like manuring, catch crops, crop rotations, P and K fertilisation etc. and refer to local field trials for results. SEGES coordinates the work and also organises local field trials, produces fact sheets and develops advisory tools, for example to calculate mineral balances on farm and field level. Information is exchanged through an online platform. Three groups are participating in the OK-Net Arable activities.

9. **VÖP in Germany** is a network of three major German organic farmers' associations Bioland, Demeter and Naturland and two private research and education organisations: Forschungsinstitut für biologischen Landbau (FiBL) and Stiftung Ökologie & Landbau (SÖL). VÖP aims to identify and aggregate farmers' research needs by working with farmers with a special interest in applied science projects, with the aim to address current challenges facing organic farming and to further develop the sector. Farmers from all kinds of agricultural sectors and climatic regions in Germany are involved. Currently, approximately 100 farmers are members of the network. They organise themselves into sub-groups to investigate specific questions. The nutrient management subgroup is currently engaging with the OK-Net Arable project.

10. **The Organic Research Centre (ORC) in the United Kingdom** is the UK's leading independent research centre for the development of organic/agroecological food production and land management solutions. ORC has established an arable farmer group for the purposes of the OK-Net Arable project. The group was initiated in order to gather farmer experience from the UK. Participants were selected in collaboration with OF&G, a UK certification body, and Organic Arable, a UK marketing group of cropping farmers.

5 Description of the farmer innovation groups

The groups selected by the practice partners are described below. These descriptions cover the establishment and aims of each group, the group size, age and gender of the members and a summary of the working modality of the group in terms of facilitation and frequency of meetings. The farming context is briefly described as well as the major challenges faced. The data that has been collected for each group is indicative of the ranges within the group. Therefore the data only enables us to discuss broad patterns and trends for further exploration as the project progresses.

Austria

Bionet Burgenland/Bionet Lower Austria
The Burgenland/Lower Austria group was established in 2005 within the framework of the nationally funded educational project 'Bionet'. The driving force was to encourage the exchange of experience between farmers, advisers and researchers. The main aim of the group is to implement field trials to assess specific plant varieties, the results of these trials are published and made available to group members and other farmers. Inspections of the field trials are organized for interested farmers in order to promote learning. There are 18 members of the group, 10 males and 8 females aged between 25 and 55. The group meetings are held several times per year and are facilitated by both group members and advisers.

Members of the group farm cereals, field crops and mixed crops with livestock. Farms range in size from 40 to 250 ha with an average farm size of 100 ha. Crops grown by the groups include wheat, barley, maize, soybean and sunflower. Soils vary but are generally silt clay loams. The group has a continental climate with the most limiting climatic factor being lack of rainfall in spring and summer. The top three production challenges identified by the group are soil fertility, nutrient cycling and climatic changes, namely increased incidents of drought.

Biokompetenzzentrum Schlägl
The Biokompetenzzentrum Schlägl ("Organic Competence Centre") was founded in 2011 by the Association of Graduates of Bioschule Schlägl (The "Bioschule" is an agricultural college with a focus on Organic Farming) and the Research Institute of Organic Agriculture (FiBL Austria) and is funded by the province of Upper Austria. The aim of the group is to conduct field trials in arable farming in order to develop site-specific organic agriculture that is relevant to producers in the region. There have been various field trials on participating farms in recent years. Information is available via a group website and interested farmers can arrange to visit the trial sites. There are approximately 8 members of the group, 4 males and 4 females aged between 20 and 55. The group meets twice a year, meetings are facilitated by college staff.

The group members farm cereals, field crops and mixed crops with livestock. Farms range in size from 20 ha to 50 ha with an average farm size of 30 ha. Crops grown include barley, rye, triticale, field beans, maize and potatoes. Soils vary but are generally brown earth with a high sand content. Soils are shallow with a low water-holding capacity. The group is within an alpine climate with the most limiting climatic factor being very cold winters. The top three production challenges identified by the group are nutrient cycling, weed management and climate change, namely drought.

Belgium

Biobedrijfsnetwerk Akkerbouw-groenten
The BioForum *Biobedrijfsnetwerk Akkerbouw-groenten (Arable-vegetables group)* was initiated in 2010, prompted by positive experiences with similar groups for fruit and dairy farms. The arable group's main focus is on soil fertility and weed management, but other themes have also been tackled such as disease and pest control, machinery, farm systems and packaging of potatoes. The group is also interested to explore other areas. The group aims to facilitate the exchange of information and experiences between farmers, and between farmers and advisers/researchers. It also strives to discuss and disseminate research outcome, discuss policy issues, identify new topics for research, and provide a space for farmers to get together and network with one another. The group involves approximately 20 members, 15 male and 5 female aged between 30 and 60. The group meets three times per year and meetings are facilitated by advisers from BioForum/INAGRO.

The group farms cereals, mixed crops with livestock and horticultural crops with an average farm size of 10 ha. Crops grown include wheat, triticale, pea/faba bean, triticale mix, potato, and many outdoor vegetables such as leek and celeriac. Soils vary widely from very sandy to clay loam, resulting in differing water holding/draining capacities. The soils are generally quite fertile. The group farms in a northern temperate climate and finds the most limiting climatic factor to be extreme weather events caused by climate change. Summers are short and regular rain increases pressure from weeds and diseases. The three most important production challenges are soil fertility, pests and disease, and weed control.

Bulgaria

Bioselena
The group was established before launching the project "OK-Net Arable". The aim of the group is to improve knowledge exchange, cooperation and the development of organic agriculture in Bulgaria. The network operates mainly in the south central region of Bulgaria with stockless arable farms and mixed farms. Farmers have been involved in testing innovative technologies with the aim of increasing the area of sustainably managed land in the country. Currently there are approximately 12 farms actively participating in the network, 7 men and 5 women aged between 28 and 52. The group meets twice per year; the meetings are facilitated by an adviser.

The group farms cereals, mixed crops with livestock, and horticultural crops, with some protected cropping. Farm sizes of group members range from 7.4 ha – 180 ha. Arable crops grown include wheat, barley, spelt, rye, triticale, millet, peas and field beans. Soils vary considerably from very high sand content to very high in clay. Most soils have low permeability making them susceptible to flooding and drought. Most soils have low levels of organic matter and are not naturally fertile. The group farms over two climatic regions, continental and Mediterranean. According to the group, the most limiting factor in both these climates seems to be a lack of precipitation in the summer. The three most important production issues are a general lack of technical knowledge and experience, pest and disease control, and weed control.

Denmark
SEGES Sjaelland
This group was initiated in 2013 as part of a project which was financed by levy money. The original aim of the group was to find solutions for nutrient supply without conventional manure. The group

operates in the Sjaelland (Zealand) region, the largest island of Denmark. There are 6 active members of the group currently, all males aged between 49 and 65. The group is closed to new members. The group meets five times per year and the meetings are facilitated by an adviser.

The group farms cereals, has general cropping and farms horticultural crops, on an average farm size of 60 ha. Arable crops grown include wheat, barley, rye, peas, field beans and oilseed rape. Soils vary across the farms from loamy sand to silty clay loam. The group farms in a northern temperate climate and sites too much precipitation in spring and autumn as the most limiting climatic factor. The three most important production issues are availability of organic fertilisers, rotations involving clover grass leys and economic issues (how to get a reasonable income).

SEGES Vejle

This group was initiated by a national funded project to reduce the use of manure from conventional farms and find alternative organic fertilizers. Members of the group were identified by the group facilitator. The group operates in the region of Vejle, southeast of the Jutland peninsula. 6 farmers participate in the group, all males aged between 40 and 60. The group is closed to new members. The members meet three times per year and the meetings are facilitated by an adviser.

The group farms cereals and cereals with field crops with an average farm size of 22 ha. Crops grown include barley, oats, rye, peas and faba beans. Soil varies but is generally sandy (loamy sand/ sandy loam). The organic matter content is fairly low and soils with higher clay content can be hard to work in the spring. The group farms within a northern temperate climate and sees the main limiting factor as a short growing season. The group has identified the three major production challenges as weeds, minerals, and management (equipment) for weeding.

SEGES Videbaek

The group was initiated in 2013 as part of project “High yielding organic arable farming without conventional manure”. The aim of the group is to share experience and learn new possibilities. The group operates in the region of Videbaek, on the Jutland peninsula in west Denmark. 6 farmers are participating in the group at the moment, all males. The group is closed to new members. Meetings are facilitated by an adviser.

The group is made up of mixed cropping farms, growing barley, rye, triticale, peas and horse beans. Soils are quite sandy (loamy sand) with low water holding capacity. The group farms in a northern temperate climate and views high precipitation in spring as the most limiting climatic factor. The three major challenges for the group are management of nutrients, minerals and weeds.

Estonia

Maheklaster

This group was established in 2015 to improve knowledge about agricultural technologies and practices in organic farming and establish new practices to achieve better soil fertility and yields. The group was initiated by EOFF in collaboration with active farmers due to a perceived need to improve organic practices and share available knowledge. There are two subgroups – one working on arable crops and one on vegetables. Both of these sub-groups had some history of internal communication and knowledge sharing before the establishment of *Maheklaster* (the more formal group). There are 20 members of the group, 16 men and 4 women aged between 22 and 51. Membership is open. The group meets 3 to 4 times per year and meetings are facilitated by members and advisers.

The group farms cereals, field crops, mixed crops with livestock and horticultural crops. Farms of the group members range from 15 ha to 1,110 ha with an average farm size of 283ha. Arable crops grown include wheat, rye, oats, peas and beans. Soils are very variable but are typically sandy loam. Overall soil fertility is moderate to poor. The group farms under a northern temperate climate, long, cold winters are the biggest limiting climatic factor and group members find the unpredictability of the weather very challenging with either too much or too little precipitation during the growing season. The top three challenges of organic arable production faced by the group are soil fertility, weed control, and pest and disease control.

France

BASE-ABC

The BASE (Biodiversity Agriculture Soil & Environment) group was initially started by conventional farmers in the area of Bretagne. Today approximately 800 farmers and technicians have joined the network. They are dispersed all over France (as well as one group in the south of England and another in Ireland). A sub-group, BASE-ABC, was created in 2015 specifically for organic farmers. This group maintains a strong link to the wider BASE network. The organic group is focused on specific questions linked to organic farming and reduced tillage. The aims of the group are to: improve organic farming systems; exchange ideas on innovative farming practices; exchange on experiences of farmers to progress together; respect the soil by reducing tillage; experiment on-farm. There are currently 22 members of the group. 11 of these members were included in the data collection exercises, 10 men and 1 woman aged between 40 and 61. The group meets once a year and the meetings are facilitated by group members.

The group farms cereals, has general cropping and some mixed cropping with livestock, with farm sizes ranging from 29 to 350 ha. Arable crops grown include wheat, barley, triticale, maize, soya and faba beans. Soils type varies through all the major textural classes from sandy loam, through silt loam to silty/sandy clay with varying levels of organic matter. The group farms in a northern temperate climate and find that the most limiting climatic factors are high precipitation in spring and autumn and not enough precipitation during the summer months. The top three challenges of organic arable production faced by the group are nitrogen management, weed management, and organic breeding & varieties.

RotAB Network

The RotAB network consists of 12 long-term farm experiments that aim to assess stockless organic arable crop systems in order to design more resilient and sustainable cropping systems. All members of the network rely strongly on agro-ecological crop management practices, for example increased use of legumes in crop rotation, incorporation of cover crops, and intercropping. The agronomic, economic, social and environmental performance of the systems' are evaluated in order to assess their robustness and sustainability. As a multi-stakeholder network RotAB encourages knowledge exchange between farmers and between researchers/advisers working on the trials. As the group is a network of long term experiments established for research purposes it has unique characteristics when compared to other farmer groups. The group meets once or twice a year and meetings are facilitated by advisers.

This group farms cereals and general cropping on farms ranging from 2.3 to 64 ha. Arable crops grown include wheat, barley, triticale, maize, soya, peas and beans. Soils vary drastically, as the groups are located all over France, from sandy loam to silty clay. The groups are spread across France and farm in two climatic regions. Group members are mainly located in a northern temperate climate and one of them in a Mediterranean climate. Across these two climatic regions the biggest limiting factors are too much precipitation in spring, and in autumn, and dry summers. The three most important production challenges are weed management, nitrogen management, and biodiversity.

Germany

VÖP – nutrient management subgroup
10 farmers from the *VÖP* network with a specific interest in nutrient management are involved in the OK-NeT Arable project. The group is located in the eastern Lower Saxony region called "Wendland". This group works specifically with farmers who have little or no livestock. The main aim of the group is to further develop the nutrient management techniques utilised by the group members, including enhancing the cooperation between farms. The group meets 4 times a year and organises farm visits to exchange ideas and knowledge. There are also plans to attend field days in the region. The group members are male ranging from 47 to 64 years of age.

The group farms cereals, general cropping, mixed cropping with livestock and horticulture. A high proportion of the members grow root crops (potatoes) and some produce vegetables. Farm sizes of group members range from 40 ha to 180 ha with an average farm size of 150 ha. The group farms within a northern temperate climate and views the major limiting climatic conditions as high rainfall in spring and autumn and dry summers. Some members of the group rely on irrigation for potatoes due to dry summers. The three major production challenges identified by the group are nutrient supply, crop rotations, and weeds and diseases.

Hungary

ÖMKi
This group was initiated by ÖMKi in 2011 in collaboration with interested organic farmers to address a specific production challenge, namely variety testing. The aims of the group are: to test wheat, emmer, einkorn, spelt and soy varieties under on-farm conditions suitable for organic farming and to test inoculants and agronomic techniques for soy production. The group encourages the sharing of knowledge and experience among members and the dissemination of information both between group members and with fellow farmers. As well as engaging in practical testing the group organizes meetings and provides publications to help expand Hungarian organic expertise. There are currently 26 members of the group, they are all males aged between 45 and 70. Members are located in Trans-Danubia (West-Hungary) and on the Great Plain (East Hungary). The group meets twice a year and meetings are facilitated by an adviser.

The group farms cereals, mixed cropping with livestock and horticultural crops, on farms ranging from 0.5-600ha. Arable crops grown include wheat, spelt, soya, sunflower and maize. Soils vary widely but a typical textural class is clay. The group farms within a continental climate and views dry summers as the most limiting climatic factor. The three major production challenges are weed management, pest management, and soil and water management.

Italy

ConMarcheBio

For the purposes of the OK-Net Arable project a sample of farmers were brought together from a larger group of farmers belonging to four cooperatives grouped under Con Marche Bio (consortium of cooperatives). The aim of this group is to grow cereals and sell them to organic processors. 49 members were interviewed, 40 males and 9 females aged between 30 and 65. The Con Marche Bio groups meet around 6 times a year. The meetings are facilitated by the advisers of the consortium.

The group mainly farms cereals; livestock are present on about 10 to 15% of the farms. The average farm size of group members is 35-40 ha. Arable crops grown include durum wheat, spelt, barley, field bean, chick pea and alfalfa (three years on average). Soils are generally clay/silt with a typical textural class of clay loam. Soils are hard to work in wet conditions and have poor drainage. The groups finds it challenging trying to incorporate green manures at the end of the winter. The group farms in a continental/sub continental climate and finds the most limiting climatic factor to be too much precipitation in the autumn. The group identified machinery for weeding and cultivations, lack of quality seed suitable for organic production, and soil fertility as the most important production challenges facing them.

United Kingdom

ORC Arable group

This group was established for the purposes of the OK-Net Arable project to ensure the inclusion of UK farmers. Meetings are held on farms of group members on a rotational basis. Members come from different parts of the UK, but mostly from the south east and south west of England. Communication takes place via email and an online Wiggio platform has been established. 9 farmers are actively involved in the group at the current time, all male aged between 30 and 60. Group meetings are held on a quarterly basis and are facilitated by ORC staff using participatory approaches. Membership of the group is open and is likely to expand over time.

The group farms cereals and undertake mixed cropping with livestock. Farm sizes range from 625 to 850 ha with an average farm size of 760 ha. Typical crops grown include winter wheat, spring wheat, oats, spelt, triticale, barley, beans, peas and clover leys. Soils are highly variable depending on the farm location. The groups farm in a northern temperate climate and find the most limiting climatic factor to be cold winters, dry summers and high precipitation during the autumn. The group identified weed management and soil fertility as the most important production challenges.

6 Comparison of key characteristics

6.1 Main aims, set up and modes of operation

The dynamics of the farmer innovation groups vary from country to country. Most of the groups were established prior to the OK-Net Arable project and as such have different aims and operational structures.

Some groups have been established with very specific aims, for example the Danish groups are researching issues of nutrient supply, whereas the BASE-ABC sub-group in France was established to explore reduced tillage options for organic farming, and the main aim of the ÖMKi group in Hungary aims is to test wheat and soy varieties under organic farming conditions. Some groups form part of a larger network of organic farmers, but have been selected to participate in the project. For example the *Biobedrijfsnetwerk Akkerbouw-groenten* group from the BioForum network in Belgium has been identified because of their focus on arable production. The BASE-ABC group is part of the larger BASE network in France. Some of the groups have been established to work with farmers from a specific region, for example ConMarcheBio in Italy works with farmers from the Marche region; the two Austrian groups have been established in specific regions as well as the three SEGES groups in Denmark. Other groups have been established to facilitate exchanges between farmers from different regions e.g. both the RotAB and BASE networks in France and the VÖP network in Germany.

The majority of the groups have been established by a research institute or have links to a research organisation. Therefore, it is perhaps not surprising that ‘knowledge exchange’ is stated as a core aim for the majority of the groups. Knowledge exchange includes farmer-to-farmer knowledge sharing as well as exchange between farmers, researchers and advisers. Four of the practice partners (and their associated farmer groups), BioForum Flanders, ConMarcheBio, ÖMKi and EOFF, go beyond farmer-to-farmer and farmer/adviser knowledge exchange and aim to connect actors across the ‘value chain’ by encouraging interactions between farmers, processors and traders and other actors from the agricultural and food sectors.

Most farmer innovation groups were established between 2010 and 2015, the oldest group is *Bionet Burgenland/Bionet Lower Austria* which was established in 2005. The group sizes range from 6 to 49 members, the smallest groups being the three Danish regional groups which have 6 members each and two larger groups of 26 members in Hungary and 49 members in Italy. However, it should be noted that the Italian ‘group’ is a sample of farmers taken from a much larger group of established farmer cooperatives and as such is atypical when compared with the other groups. Based on facilitator observations, the newer groups have fewer sub-groups and less informal meetings which may indicate that group dynamics may be influenced by the length of establishment.

All of the groups have some kind of facilitator, mainly agricultural advisers or staff from the ‘practice partner’ organisations, who takes responsibility for coordinating the group. Feedback from the groups indicates that the facilitators are usually very committed to their role, some even spending their spare time contributing to the group’s development. In some cases farmers also play a facilitation role, e.g. Austria *Schlägl*, Estonia and France, but this is usually supplemented by a researcher or adviser.

Facilitation seems to be informal and mostly entails coordination of meetings and bureaucratic jobs associated with producing information and ensuring communication between the members. It is not clear whether 'facilitators' are given any professional facilitation training in order to help with the management of the groups. As such it is likely that the style of facilitation will vary between the groups. For example, the regular meetings of the ÖMKi group in Hungary are reportedly relatively formal in style with lectures about specific research topics and field visits. Face-to-face meetings with group members also take place between these meetings which are more informal. Professionally facilitated discussion is not typical among the groups. This is interesting because apparently there is an increasing demand among agricultural advisers for the development of 'soft skills' such as teaching methodologies, coaching, general advisory techniques, management of difficult situations in advisory work and communication (Opancar 2014, 22).

All groups have regular meetings, the frequency of meetings ranges from once a year to once a month. The Estonian group currently meets on monthly basis, because it has only been recently established and frequent meetings are often required during the early phase of group formation. The group aims to meet between 3-4 times per year in future. On average, most of the groups seem to meet two to three times a year. Most of the meetings are held on farm. In addition to these meetings most groups organise field days, workshops, seminars or meetings about specific topics of interest to the group members. The topics of these field days, seminars and training events vary and are sometimes determined by researchers or advisers and sometimes by the farmers. For example, the last group meeting of the *Bionet Burgenland/Bionet Lower Austria* group was on the topic of sustainability assessment; this topic was decided by researchers. Meetings on special topics are also organised once a year by *Biokompetenzzentrum Schlägl*, for the last two years the topics have been decided by researchers.

Email, telephone and SMS messages are the most commonly used methods of communication between meetings. Use of other online communications tools, such as Dropbox (BioForum Belgium and RotAB France), Wiggio (UK) and group websites (BioNet Austria) are used by some groups but are not common. The ÖMKi group in Hungary use a mailing list called 'Listserve' to communicate with members but there is low activity mainly consisting of one-way communication from the coordinator to farmers. The RotAB France network is planning to utilise an intranet website in the future. Some group members use social media platforms for communicating and sharing information between meetings, for example some members of *Biobedrijfsnetwerk Akkerbouw-groenten* in Belgium use social channels but do not specify which ones, and some group members in *SEGES Sjaelland* (DK) use Facebook, but this is not common. Among members of the *ConMarcheBio* group in Italy social media is mostly utilised by younger group members. BASE France uses a mailing list to share information between members. Various dissemination tools are being used successfully by the groups, for example meeting reports are written by facilitators in Denmark and digital newsletters are circulated by BioForum in Belgium to keep members updated.

6.2 **Who are the members**

The members of most groups are a mix of new entrants and experienced organic farmers. Most groups include farmers who have farmed organically for over 10 years. Groups that include the most experienced farmers, in terms of the length of time they have farmed organically, are BASE-ABC in France (35 years), both Austrian groups (30 years) and *SEGES Sjaelland* in Denmark (33 years). Groups in the new members states seem to have less experienced members when compared with other groups, for example in the *Bioselen*a group in Bulgaria the most experienced members have been farming organically for up to 12 years and the most experienced members of the *Maheklaster* group in Estonia have been fully organic for up to 11 years. This perhaps reflects a later uptake of organic methods in these countries, compared to other EU countries where organic production is more established. Most groups do not have an official 'leader' but it is recognised that certain farmers within the groups have more technical knowledge or experience than others, which corresponds to group dynamics in terms of age range and length of time that members have farmed organically.

The age of the members across the 14 farmer innovation groups ranges from 20 to 70. Groups in some countries, namely Austria and Estonia have younger members than other groups, the youngest members across the groups are aged between 20 and 25. Certain groups seem to be older in their composition for example, e.g. the BASE-ABC group in France whose members range from 40 to 62 and two of the Danish groups whose members range from 49 to 65 and 40 to 60. The oldest group member is from ÖMKi Hungary at 70 years old. Individual responses to the online questionnaire (part 3 of the monitoring framework) indicate that most groups consist of people aged 40 and above and generally have a lower proportion of younger members. The Danish and Italian groups particularly seem to have a higher proportion of older members, which reflects broader trends reported in both countries in terms of an ageing farming population (Madsen-Østerbye 2014, Caggiano 2014.

All of the farmer groups consist mainly of male members; which is unsurprising as agriculture has traditionally been a 'male' occupation. However, it should be acknowledged that although female representation in the groups is low, women play a significant role in agricultural systems, particularly in terms of provision of agricultural labour and for farms that depend on family labour. According to the PRO AKIS country report 35% of women are employed in the agricultural sector in Flanders (Labarthe & Moumouni 2014), and 33.3% of farms in Italy are managed by women (Caggiano 2014). In the UK, Denmark and Hungary the farmer groups are exclusively male. The highest female representation seems to be in Austria where the groups are half male and half female which perhaps indicates that this is an intentional target.

Almost all of the groups are open to new members, apart from in Denmark where groups are closed, (although this is soon to be changed to open membership). It is not clear whether farmers are required to pay a membership fee to join the groups, although comments from some of the group facilitators suggest that membership of the groups is free. As most of the groups are open it is likely that there is some fluidity in terms of membership, which may have some influence on group dynamics. For example, the group in Belgium is open to all organic farmers with arable or vegetable crops, the facilitators have commented that the group composition changes over time. Similarly the people attending the *Bionet Burgenland/Bionet Lower* Austria group meetings are always different which means that the dynamics vary from meeting to meeting. In Hungary the country-wide spatial distribution of the networks mean that it can be challenging to organise a meeting where all partners are present for each meeting. The fluidity of the group membership should be borne in mind when considering the challenges that have been identified, i.e. these may only be reflective of challenges prioritised by group members at one particular point in time.

7 Summary of agronomic and climatic context

The selected farmer innovation groups operate in geographic regions representing important climatic and environmental conditions for arable crops in Europe. The areas reach from Denmark and Estonia, over Austria, Belgium, France, Germany, Hungary and Bulgaria to Italy.

Groups are located mainly in three European **climate zones**: over half of the farmer groups (9 out of 14) are located within the northern temperate climate zone: Belgium, three Danish groups, Estonia, UK, two French groups and Germany. Four of the groups are located within the continental climate zone: *Bionet Burgenland* in Lower Austria, *Bioselena* in Bulgaria, Ö*MKi* in Hungary and *ConMarcheBio* in Italy. The *Biokompetenzzentrum Schlägl* group in Austria is the only group located in the alpine climatic zone. *Bioselena* in Bulgaria and *RotAB* in France have members located in the Mediterranean climate zone, as well as the continental and northern temperate zones respectively.

All the OK-NeT Arable farmer groups contain members who are working on land that is situated at different **altitudes**. Seven of the groups only contain farmers who are working below 300 m above sea level (masl) Belgium, Hungary, Estonia, the three Danish groups and the *RoTAB* network in France. Six of the ten groups have farmers working land at between 300 and 600 masl: Austria, Bulgaria, France, Germany and Italy. Only two groups, in Bulgaria and France, have farmers who are farming above 600masl. Two groups, *Bioselena* in Bulgaria and *BASE-ABC* in France, have members farming across all three altitude groups indicating a variation of agronomic and climatic conditions between the group members.

In terms of **annual rainfall**, the ranges vary from group to group depending on geographical location, with expected trends for high rainfall observed for groups located along the eastern coasts of water bodies (due to the prevailing westerly wind flow) and for groups farming at altitude. Rainfall also can vary considerably within one group of farmers. For example, a range of annual rainfall between eastern and western locations in the UK was reported from 592mmyear^{-1} (West) to 857mmyear^{-1} (East).

There are however some similarities across all groups with most groups receiving an annual rainfall of between 300mm to 900mm per year. Very few farmer groups receive rainfall of higher than 900mm per year with *BASE-ABC* in France the only exception with a maximum of 1100mm. Where data giving the average (instead of the range) of annual rainfall are presented, these averages are with-in 600 to 700mm (*Bioforum* in Belgium and *Maheklaster* in Estonia). Furthermore, the averages of several groups whose ranges are reported lie between 600mm to 700mm (*Bionet Burgenland* and *Biokompetenzzentrum Schlägl in* Austria, *SEGES Sjaelland* in Denmark and *VOP* IN Germany).

Virtually all farmer groups have a maximum annual rainfall of between 700mm and 900mm annually. Minimum levels of annual rainfall differ more widely across the groups with a much larger range of between 300mm to 750mm. It appears possible to infer from this that all groups may have an issue with too much rain, but only a few groups (in particular both Austrian groups, members of Bioselena in Bulgaria and ÖMKi in Hungary) see a lack of rain (drought) as a production issue. Although data on average annual rainfall can be instructive it does not tell us anything about the temporal distribution of the rainfall which can be more informative. For information on this we turn to the group’s most limiting climatic factors.

The limiting production factors vary between countries and are influenced by the climatic zones in which the groups are located. Overall the northern temperate climate zone is associated with a short growing season and too much precipitation in spring and autumn, unpredictability of rainfall and extreme weather events. The continental climate zone is associated with lack of precipitation in the summer or too much precipitation in autumn. The alpine zone is associated with cold winters.

In terms of rainfall, SEGES Sjaelland (DK), BASE-ABC (FR), RotAB Network (FR), VOP (DE), Con Marche Bio (IT), and ORC Arable group (UK) listed high rainfall in autumn as a limiting factor. Sjaelland (DK1), Videbaek (DK), BASE-ABC (FR), RotAB Network (FR) and VOP (DE) groups listed high spring rainfall as a major limiting factor. All groups that listed too much rainfall in autumn or spring as an issue are located within the Northern Temperate climatic zone. Although wheat producing members of ÖMKi (HU) group, located in the Continental climatic zone report high ground water levels in spring causing production problems, and high rainfall in autumn leading to poor wheat quality and delayed soya harvest. Bionet Burgenland (AT), Bioselena (BG), BASE-ABC (FR), RotAB Network (FR), VOP (DE) and ÖMKi (HU) groups identified dry summers as a limiting climatic factor though these groups do not fit neatly into one climatic zone, spanning three zones of Northern Temperate, Continental and Mediterranean. Interestingly, Bioforum Flanders from Belgium was the only group to identify wet summers as a climatic limiting factor (heavy summer storms which result in problems with late blight in potato and makes mechanical weed control difficult for 2 or 3 weeks).

Certain groups have also reported changes in the climatic conditions, for example in Austria where farmers are experiencing increasing incidents of drought, and many of the groups report problems due to unpredictable rainfall. **See Table 1 in Appendix.**

7.1 **Farming systems**

The farmer innovation groups represent a range of farm types including cereal producers, organic mixed farms, including livestock and field vegetables (e.g. potatoes, cabbage, leeks etc.), horticultural farms as well as stockless arable cropping systems. The majority of the farms are rain fed, although in Denmark the Videbaek farms use irrigation for sandy soils, in Hungary vegetable producers from the *ÖMKi* group irrigate their fields from wells or canals, irrigation structures are also reported in Bulgaria, and Italy.

In terms of typical crops grown most groups appear to be focused on cereal crops. Some of the groups have more of an emphasis on field and horticultural crops than others, e.g. Belgium where members of the group produce potato and other vegetables such as leek and celeriac. Bulgarian group members produce peppers, cucumbers, raspberries, pumpkin and tomato and members of the Estonian group produce carrot, cabbage and turnips as well as a range of other vegetables. The *RotAB* network (FR) has a specific focus on stockless systems, as do the three SEGES groups in Denmark who are aiming to reduce reliance on conventional manure.

The groups are predominantly arable focused, reflecting the focus of the project, but there are mixed farms among the group members. The typical number of livestock holdings reported across the groups is low due to the arable focus of the groups. Groups do include mixed farms. Cattle are the most common livestock type kept by groups, reported from Austria (*Schlägl*), Belgium, Bulgaria, Estonia, France (*BASE-ABC*), Hungary and Italy. Goats are kept by group members in Austria (*Schlägl*) and Belgium; sheep by members of groups in Austria *(Schlägl)*, Estonia, Hungary and Italy. Group members in Austria (*Schlägl*) keep pigs and keeping poultry was only reported by members of the *Burgenland* group in Lower Austria. *Schlägl* group members in Austria seem to be more livestock oriented than members of other groups with more livestock types and higher stocking rates reported. This is possibly because there are many mixed-cropping farms in this area with grassland, and the group also works on intensive/extensive grassland cultivation indicating the potential for livestock integration within the farming systems.

Farms across the ten countries include a range of ecological features. All groups report that their farms include hedgerows which are important features for on-farm biodiversity. Types of hedges include both old established and newly planted ones. Some groups report the presence of wooded and forested areas on their farms e.g. Bulgaria, Austria *Schlägl*, Denmark Vejle, Estonia and France. Also water features are mentioned: Bulgarian farms have irrigation canals, lakes and ponds, Hungarian farms feature canals and Italian farms feature water ditches. Some groups have a specific interest in incorporating more ecological features into their farming systems in an attempt to increase biodiversity, for example the RotAB group in France try to manage and improve biodiversity by implementing agroecological features such as hedgerows and grass margins and agroforestry systems. This emphasis on agroecology is a stated aim of the network.

Farm sizes between the groups range from the smallest at 0.5 ha in Hungary to the largest of 1,110 ha in Estonia. Farm sizes vary markedly within the groups with some wide ranges reported, for example 17 ha to 300 ha in Denmark *Sjaelland*, 0.5 ha to 600 ha in Hungary, 5 ha to 300 ha in Italy and 15 to 1110 ha in Estonia. Despite these ranges, generally the land holdings of group members appear to be larger than reported average land holdings for the individual countries, possibly due to the arable focus of the groups. For example, all members of the UK group have holdings larger than the national average of 77 ha (Prager, & Thomson 2014). However, many of the groups have some members with smaller areas of land than national averages, for example in Belgium where the smallest reported land size of a group member is 1ha compared to the average of 25ha in Flanders (Department of Agriculture & Fisheries 2015). The average size of agricultural holdings varies from country to country, and between regions within specific countries. According to information from the monitoring framework, group members from the *Schlägl* group in Upper Austria seem to have smaller farm sizes than group members from Burgenland in Lower Austria, which may be a reflection of the different regions where the groups are located. Similarly members of the group from *SEGES Vejle* in Denmark seem to have larger areas of land than the *SEGES Sjaelland* group, and larger average holdings at 220 ha than the national average of 66ha (Madsen-Østerbye 2014).

7.2 **Main crops grown, yields and rotations**

Crops

As would be expected of organic arable systems, crop group diversity is higher than conventional farming systems with cereals less dominated by wheat and barley, although all farmer groups surveyed grow at least one of these major cereals (with seven groups growing both). The other cereal crops grown are: triticale, rye, spelt, oats, millet and durum wheat. Rye is grown by farmers in Austria, Bulgaria, Denmark and Estonia. Spelt is grown by farmers in Belgium, Bulgaria, Estonia, Hungary, Italy and the UK. Triticale is grown by farmers in Austria, Belgium, Bulgaria and France. Oats are grown by farmers in Denmark (Vejle), Estonia and UK. Millet is grown in Bulgaria and durum wheat in Italy.

Grain legumes feature highly amongst the rotations with all groups growing at least one of these crops. Most common are peas and field beans with ten groups growing one or both of these crops. Less common grain legumes include soya beans (*Bionet Burgenland*, France and Hungary), chickpeas (Italy) and lentils (France). Winter oil seed rape is only grown by members of one of the Danish groups (Sjaelland) reflecting the challenge of growing this crop organically. Sunflowers are produced in Austria Burgenland and Hungary, and sesame in Bulgaria. Maize is grown by several groups (Both Austrian groups, Bulgaria, Belgium, both French groups and in Hungary).

Grass-clover mixes are grown by members of five groups: Austria *Schlägl*, Belgium, *Maheklaster* in Estonia, BASE-ABC in France and members of the ORC group in UK. It is no surprise that grass/clover leys are utilised by farmers without stock and where these leys are not used, lucerne is grown instead as an alternative forage legume (Bioselena Bulgaria, ÖMKi Hungary, RotAB Network and Con Marche Bio Italy). Two groups use both grass-clover and Lucerne as forage legumes (*Schlägl* Austria and BASE-ABC France) and these groups have cattle stock in their systems. It must be noted that although grass/clover mixes are only mentioned as a typical crop by some of the groups, most groups include them as part of their typical rotations.

Root crops are grown by some groups with *Schlägl* in Austria and the Belgium group growing potatoes, and the Estonian group growing carrots. Other field vegetables are grown but these are limited to the Belgium, Bulgarian and Estonian groups.

Yields

Yields of the major crops grown vary between groups across Europe but also within each group. Variation in yield is likely to be a result of physical variations (i.e. climate and soil) as well as differences in management practices. Although there do not appear to be clear trends in terms of climatic zones, generally in terms of cereals grown, northern temperate groups from Belgium and Denmark tend to achieve the highest yields and groups based in Bulgaria and Estonia tend to have lower yields. **See Table 2 in Appendix.**

Wheat: In Bulgaria the reported variation in yields across the group ranges from 0.3 to 8 t/ha. Excluding this group, yields range from 1 to 6 t/ha with a likely average somewhere around 3t/ha.
Barley: The yield range is 1 to 7 t/ha although only Belgium reaches yields that high with most groups reporting yields between 1.5 to 6.5t/ha.
Triticale: The picture is similar to barley with an overall range in yield between 1 t/ha and 9 t/ha. Again it is only the Belgian group that reports such high yields with the five other groups growing the crop failing to exceed 6t/ha. The lowest yielding group are BASE-ABC in France who yield as low as 1t/ha.
Rye: The range of yields is less variable (1.2-6.5 t/ha) with the highest yields from Sjaelland in Denmark, and the lowest in Bulgaria.
Spelt: Yields range from 0.8 – 5.5 t/ha with Hungary yielding highest and Bulgaria yielding lowest.
Oat: Yields range from 1.6 t/ha to 6.5t/ha with Vejle, Denmark having the highest yield and Estonia having the lowest yield.
Maize: Crop yields range between 0.8 and 15t/ha with *Schlägl*, Austria reporting yields of 10-15t/ha while Bioselena, Bulgaria reported yields of only 0.8 to 2.5 t/ha.

The only **root crop** grown by more than one group is potatoes and yields for these vary drastically in the Belgian group from 15 to 40 t/ha. Yields are less varied in Austria (*Schlägl*), ranging from 15 to 25 t/ha.

Faba bean: Yields vary from 0.5 to 5 t/ha across all groups. The lowest yielding group farms in Bulgaria while the highest yielding group is Sjaelland in Denmark. Pea yields are less variable than faba bean yields ranging from 1 to 4.5 t/ha. Vejle Denmark has the highest yields while RotAB France has the lowest. Estonia also has quite low yields in comparison with the other groups.

Soya bean: Yields range from 0.5 to 4 t/ha with a relatively small range of yields within each group. Hungarian yields are lowest, with both French groups yielding highest.

Grass clover: yields between 5 and 12t DM/ha have been reported across the groups with Belgium yielding highest and *Schlägl* in Austria yielding lowest.

Lucerne: Yields vary widely from 0.5 to 15t DM/ha. The Bulgarian group has the lowest yields while the highest yields are from the Italian group but there is a wide range of yields reported from this group of 4.5 to 15t DM/ha.

The data suggests there would appear to be a need to improve yield performance and stability. Though the highest yields achieved are comparable with conventional yields (particularly for grain legumes) there is clearly a much bigger spread and greater variation. The Bulgarian and Estonian groups frequently reported the lowest yields while the Belgian and Danish groups often reported the highest yields. This also indicates that it should be possible to improve average yields through knowledge exchange aimed at improve agronomic practises through the activities of the project.

Rotations

Variations in rotation exist for a number of reasons, with climate and soil type determining to a large extent the suitability of certain crops for inclusion in the rotation and the mix of enterprises on the farm impacting on what is grown. Typical rotations, as reported by the groups, range from three to nine years with huge diversity among each group.

Most rotations described by the groups contain a fertility building grass/clover ley but there are examples of rotations with no ley included, where N fixation is provided by the inclusion of a pulse crop or the inclusion of an alternative forage legume such as lucerne. Eight of the groups include a grass clover ley in the example rotations they described with the length ranging from 1 to 4 years. The grass/clover ley comprises 0-60% of the rotation across all groups. It must be stated that even when a grass/clover ley is not included as an example of a typical rotation for a group, some members of that group do incorporate grass/clover leys in their rotations (hence an example rotation presented for a group may not describe what all group members implement in practice).

In terms of percentage of the rotation, cereals make up by far the largest proportion (approximately 50%), followed by grass/clover (25%), grain legumes (15%) and root crops/field vegetables (10%), though again the huge variability among farms must again be emphasised. As an example, a typical rotation offered for the Italian group is a 3 year rotation of durum wheat-bean-spelt, while an example of a rotation from BASE-ABC in France is lucerne – lucerne – wheat – soya –soya –lentil – wheat. The data indicate considerable variation in rotation between and within the groups but do not allow detailed analysis of any impact of rotations on yields. This would only be possible with individual farm data.

7.3 Soils

As part of this report it is only possible to make simple comparisons of the soils in terms of edaphology and more specifically soil organic matter (SOM). It is necessary to note that soil texture, climate, landscape and management all contribute to the SOM and so SOM levels between groups and farms will be as diverse as the farms themselves, however, reported SOM levels serve as a good guide to the various soils given SOM's contribution to a number of diverse soil functions that promote crop growth. A thorough comparison of soils is beyond the remit of this report, and would be challenging due to the huge variation between different countries, regions within countries and between fields on individual farms.

Typical SOM values seem to be around 3%, although there is high variability. The range of SOM reported across the groups is 0.5 to 20% though only the *Schlägl* group in Austria reports levels that high. All other groups report values between 0.5 and 8%. Nine groups have SOM levels of 5% or lower. Although groups from Belgium and Denmark tend to achieve the highest crop yields (particularly for cereals), their SOM levels are not necessarily the highest.

7.4 Main challenges identified

The results presented here are based on a facilitated process carried out in each group, collecting views from the farmer group about challenges and solutions, innovations and tools for knowledge exchange in a co-ordinated way. Some main general challenges are reported by all groups, but depending on regions and climate, the prioritisation of the main challenges differed. While for some groups the main issue is weed management, other groups have highlighted soil fertility or disease control as their most pressing challenge. In the following section we report on some of the challenges that are highly rated by all the groups. It is important to emphasise in this section that the results are reported for the whole group and not for individual farms. **See Table 3 in Appendix.**

Weed management

Weed management was mentioned by 12 out of 14 groups as one of their top three issues (this includes one group who mentioned weeding equipment). This challenge was ranked number one by 4 of the groups.

The most commonly occurring weeds across the groups are thistle (*Cirsium*) and fat hen (*Chenopodium album*), both mentioned by seven groups, and docks (*Rumex L*.), mentioned by six groups. Some other common weeds reported are couch grass (*Elymus repens*) mentioned four times, wild oat (*Avena*), chickweed (*Stellaria media*), knotweed (*Fallopia*) and mayweed (*Matricaria*), all mentioned by three groups. Perennial ryegrass (*Lolium*), charlock (*Sinapsis arvensis*), ragweed (Ambrosia) and annual meadow grass (*Poa annua*) were all mentioned by two groups. Blackgrass (*Alopecurus myosuroides*) was reported as a problem in the UK, but not in other countries. Quickweed (*Galinsoga*) was also mentioned as a problem in Belgium, particularly for vegetable farms.

Approaches to weed control vary between countries, as do the weeds. As a cornerstone of organic farming it is unsurprising that all groups mention crop rotation as a control strategy for many weeds. More interesting are the different approaches taken, with several groups using intercropping and cover cropping to create competition and help suppress weeds. In several groups grass clover leys are mentioned as a key strategy to control annual and perennial weeds and one group uses nurse cropping to establish perennial legumes. Control strategies vary from system to system with higher value vegetable crops tending to be mulched and manually weeded, with one group using flame weeding.

Some groups report on incorporating row crops into the rotation in order to allow for inter-row hoeing as a weed control strategy. There is a general trend towards mechanical weeding with several groups mentioning innovative machinery such as the *kvik-killer* for perennial weeds or the *combcut* for selective intercrop weeding. Of the groups that mention using mechanical weeding strategies, several have highlighted the cost of specialist machinery as a barrier to implementing such strategies and the need to share such equipment and cooperate with neighbouring farms.

Another trend appears to be towards low inversion tillage and the use of machinery other than a plough to perform cultivations. The chisel plough and sub-soiler are used by one group and minimum/conservation tillage is mentioned by several more as a way to discourage annual weed seed germination. Some groups appear to use “biological tillage” from cover cropping and green manures to perform cultivations and offer competition for weeds. Green manures are also used to improve soil structure as some arable weeds favour compacted, waterlogged soils.

Crop management as a tool for weed control is mentioned by three groups who use sowing date, sowing density and optimum crop nutrition to help the crop out compete the weeds. Although only three groups are explicit about the use of crop management, it is very likely several, if not all, groups employ this strategy in combination with a varied rotation.

There does not appear to be a trend towards one strategy or another depending on types of weed present, although groups with a high perennial weed burden such as *SEGES Vejle* in Denmark report needing to use a combination of all strategies and mechanical weeding becomes more crucial. Two groups are explicit about the lack of knowledge and advice available on weed control and weed suppressive rotations.

Weed control strategies are incredibly farm specific and depend on the weeds present, the farming system, the climate and soil moisture as these play an important role in the efficacy/feasibility of mechanical control. There is however a commonality in several of the major weed species (docks, thistles, couch, fat hen, wild oats) causing issues for farmers across Europe and in some of the control methods and control barriers (cost of machinery and lack of knowledge). Farmers are also aware of the connections between weeds and underlying soil fertility issues, i.e. weeds as indicators of soil fertility issues were mentioned by groups in Belgium and the UK.

Soil fertility:

Soil fertility was mentioned by 8 out of the 14 groups as one of their top three issues, and ranked number one by 4 of the groups. The issues surrounding soil fertility for the farmer groups appear to be four-fold: 1) how to effectively design and manage rotations for maximum fertility; 2) what off-farm inputs to include, when to apply them and how to get hold of them; 3) how to cultivate soil to maintain fertility; 4) knowledge gaps on how to manage the system for maximum fertility and how to measure soil fertility using soil and plant tissue analysis.

All groups use rotations to build fertility with the inclusion to a lesser or greater extent of fertility building grass clover (or other forage legume e.g. Lucerne) leys. To compliment this fertility building phase, several groups include grain legumes such as faba beans as a fertility building cash crop. Five groups mention the use of cover cropping and the inclusion of green manures to help manage the nutrient supply though issues around incorporation in the spring exist. One group mentions the use of “cut and carry” as a method of transporting fertility around the farm. Several groups have highlighted the importance of using catch crops to limit the amount of nitrogen leaching, with one group using intercropping of a grain legume and cereal for a “catch and release” system where the legume provides nitrogen to the cereal crop.

The stockless systems often rely on off farm inputs to build fertility and there are several issues associated with this. It is easier for farmers with stock to integrate grass clover leys and this can be valuable in terms of providing forage with the added benefit of providing manure and slurry for on farm use. Farmers with stockless systems have to be more creative and innovative and two groups mentioned exchanging forage or manure with neighbouring livestock farmers, while two groups mention supplying biogas plants with green waste in exchange for digestate. Issues for farmers wishing to exchange their forage are the limited numbers of organic livestock farms and organic biogas plants. Nutrient cycling is an open system as grain is exported off farm and three groups see using sewage sludge or city compost as a way to close the cycle. There is a trend for groups located in Denmark, Austria and Germany to discuss the use of both sewage sludge and biogas digestate for use as fertiliser.

There is recognition from one group that different manures may need to be applied at different points in the rotation to maximise the benefits while reducing the risk of leaching by applying liquid manure to grassland and solid manure to arable land. Three groups mention the additional use of soil improvers/activators with sea minerals, rhizoctonia inoculation and mycorrhizae to improve fertility. Only one group is explicit about the need to increase soil organic matter with the addition of manure, compost and organic fertiliser to improve fertility and only one group expresses the need to manage nutrients other than Nitrogen.

Tillage is mentioned by three groups with respect to soil fertility, with reduced/min-till used to improve fertility by reducing the oxidation and subsequent loss of soil organic matter and nitrogen. One of the groups requires more information on cultivations and their effects on nitrogen loss and a further two groups mention the knowledge gap and the need for extra information and advice about soil fertility management and more specifically, how to increase soil organic matter (including storage and application timing), legume species for intercropping, cover crop management and undersowing, and nitrogen mineralisation. Two groups rely on systematic nutrient testing and analysis of soil and plant tissue in order to guide management and it would appear that more groups could benefit from this approach.

Farmers across the groups seem to conduct some kind of soil analysis on an irregular basis; the specific types of testing were not mentioned. On average testing occurs every 5 years. The longest reported period between testing is 8 years in Austria *Schlägl*, and the shortest is every year by members of the BASE-ABC network in France.

As with the weed control issue, soil fertility management is specific to the farming system and to an extent the climate which dictate management strategies. It appears that all key nutrients could be limiting factors in terms of yield. Nitrogen is supplied to the system using legumes, but this remains challenging for stockless farmers that also have the greatest issues providing other nutrients to the system. Regulations surrounding the use of off farm manure, sewage sludge and digestate make the issue of managing soil fertility difficult for stockless organic arable farmers despite the sustainability of these nutrient sources.

Pests & diseases:

Pests and diseases were mentioned by 5 out of 14 groups as one of their top three challenges, but were ranked number one by only one of the groups. Pests and diseases differ from group to group and are heavily influenced by the climate, soil, crops grown and the crop rotation. These factors also make the risks variable from year to year. Generally groups with more of an emphasis on horticultural and field crops, namely Bulgaria and Estonia, reported a wider range of pests and diseases due to a greater diversity of crops.

Several of the diseases mentioned by the group thrive in temperate, cool, wet and humid conditions and the most commonly reported include rusts (particularly yellow rust; *Puccinia striiformis*) mentioned by eight groups, late blight (*Phytophthora infestans*) mentioned three times and mildew (powdery; *Blumeria graminis* and downy; *Peronospora farinose*) also mentioned by three groups. Commonly reported pests include pollen beetles (*Meligethes spp*), wireworm (*Agriotes spp*.) and aphids (*Aphidoidea spp*.).

The groups that include pests and diseases as one of the top three production challenges all report using rotations, drilling date, tillage and variety selection to help mitigate the risk factors and threat. The majority do use biofungicides and bioinsecticides certified for use under organic standards and these are usually copper/sulphur based, though neem oil is also used. There are issues for the groups surrounding a lack of resistant crop varieties, and certified plant protection products. One group mentions the use of pheromone traps.

The necessity to protect crops has encouraged members of one group to experiment with using home-made compost infusions to deal with the issue, with another group mentioning the use of nettle manure as a soil improver. Four groups mention pollen beetle as a problem (it should be noted that three of the groups are from Denmark) and the lack of direct control options once the pest reaches threatening levels, and the relative speed of outbreak, could be one reason why so few groups include oilseed rape in their rotations.

There are also built in conflicts arising from management strategies. For example, where ploughing in residues may help to limit carry-over of disease from crop residue it is clearly at odds with the aim to reduce the intensity of tillage. Also, one group mentions the use of certain green manures to control nematodes but this may increase the number of brassicas in rotation, increasing the risk of soil-borne diseases such as club root.

One group, Bioselena in Bulgaria, has explicitly mentioned the need for more information on plant protection products and better forecasting of pests and disease to help inform management strategies. In Belgium, damage to crops from wild animals and birds is a major concern and netting of crops causes much additional work for farmers and is sometimes not sufficient to protect crops from rabbits and deer. They have also experienced problems with crows (*corvids)* pulling out cereal, maize and vegetable seedlings. Bird damage also makes crops vulnerable to weed infestations.

Other issues

Other highly ranked issues included: lack of knowledge and research, problems with nitrogen management, nutrient cycling, challenges with grass/clover rotations (how to get more clover in the rotation), soil water content, cultivation issues, climatic changes, availability of organic seed. Many of these issues are interrelated and connect with the three most frequently cited challenges outlined above.

In addition, some specific challenges are mentioned, for example varieties of durum wheat to be cultivated in an organic environment in Italy. Apparently there is low availability of seed varieties for cereals that are suitable for organic arable producers. It is mentioned that varieties have been selected for conventional agriculture and tend to be of poor quality, this issue of low quality also affects the 'processing quality' required for producing high quality pasta. New wheat cultivars are required. The ability of farmers to exchange seeds is also restricted. Such context specific challenges perhaps serve to increase the variation of tools and materials that can be tested by the various groups, and represents the diversity of challenges in the arable sector.

In addition, some of the groups stated that they focused on the main production challenges, often focusing on technical issues, but other important issues were not necessarily highlighted. For example, members of the *ConMarche Bio* group in Italy also cited challenges such as the application of the Rural Development Plan in the Marche region, delay of payments from the regional administration, low prices of crops and certification fees. According to the group coordinator, the design of suitable crop rotations is affected by strict market limitations. This highlights potential economic issues which were not identified as a priority challenge by any of the groups, but economic considerations are likely to significantly influence the farmers' choice of crops and management strategies.

7.5 **Solutions proposed**

All of the groups have been working on various methods for addressing the challenges that they face in their farming systems. The solutions that were mentioned by the specific groups for the top three prioritised challenges are outlined below but it is not known whether the solutions proposed have been adopted by all or only some members of the group.

Weed management

The group in Austria *Schlägl* already uses nurse crops and intermediate crops for weed management, and would like to use the method of intercropping though they require more knowledge on the subject and have issues with the availability of organically grown seed for intermediate crops. The cultivation of potatoes with a layer of mulch has been implemented but there is a shortage of green crop material for farms with livestock.

The *BioForum* group in Belgium are already use crop rotation as a technique for weed management but the group feel more research is needed to design a more weed suppressive rotation. The group also felt that a greater understanding was needed of the underlying issues with soil/rotation of which a given weed may be a symptom. There was a focus on machinery as a major solution though more research and development is required, and the need to cooperate with neighbours to share the cost of new machinery was identified.

The *Vejle* group in Denmark uses rotations and adapts their management depending on weed pressures, for example they do not grow catch crops when cultivations for controlling couch grass or docks are needed. The group focus on ensuring good crop nutrition to help the crops compete against weeds. The group have found that weed pressure can increase year on year without careful management but at the moment this pressure is not causing significant yield suppression. There is a concern that the competition from weeds may very suddenly become a yield limiting factor in the future, requiring high investments in machinery.

In Estonia, the *Maheklaster* group uses crop rotations, cover cropping and mechanical weed control (harrowing, ploughing) to control weeds, and mulching and flaming to control weeds in vegetable crops. Smaller farms growing vegetables use manual weeding but this is labour intensive and specialist machinery is prohibitively expensive.

The group *BASE-ABC* in France uses crop rotations to break weed cycles, and integrates grass leys and cover crops to help control weeds. The group aims for maximum soil coverage using intercropping and cover crops to provide competition for weed species. Stale seed beds, tillage and mechanical weed control using harrows, hoes, and combcut are also used, as well as manual weeding. The group are careful to drill clean seed and use clean machinery to avoid the spread of weed seed.

Members of the *RotAB* network in France also use crop rotation as the main tool for weed control. More specifically, integration of grass leys, diverse cropping, cover crops, and the inclusion of row crops where mechanical weed control is facilitated are some of the strategies used by the group. In Germany variety choice is one of the main factors for dealing with weed issues but the group also believe in optimizing crop nutrition to help crops compete with weeds and resist disease. Under sowing is another management option used to control weeds. High plant populations are another strategy to increase the competitiveness of the crop against weeds. No tillage systems are used to reduce weed germination.

In Hungary the *ÖMKi* group use intercropping (e.g. red clover and maize, winter wheat and a legume, or volunteer oats and peas) to offer competition against weeds. Row crops are managed with inter-row tillage using special equipment like a weed harrow. The group try to keep as much of the arable land cropped for as long as possible to prevent weed emergence and development. Crop rotation is an important tool in suppressing weeds and drilling date is utilised for improved weed control. Growing green manures such as “tillage” radish to penetrate a hard plough pan and create a good tilth is another strategy employed. Some group members use manual weeding and hoeing to control weeds.

In Italy members of the *Con Marche Bio* group use a chisel plough followed by harrowing to help in the control of *Rumex spp*. Soil preparation for wheat is postponed until the end of August with false seed beds created using a tine harrow. Some group members use a subsoiler rather than a plough to help control weeds and preserve soil but this only works in certain regions. In areas where weeds are harder to control the plough is still necessary.

Soil fertility

In Austria, members of the *Burgenland* group are currently addressing soil fertility issues using rotations including clover grass leys and legumes. Catch crops are also grown, where possible, to reduce nutrient leaching. The group is interested in exploring agroforestry, evergreen cropping systems using green manures, minimum tillage and mycorrhizal associations. The group is also concerned about an open nutrient cycle in which nutrients are exported off farm in harvested material. Importing sewage is a suggestion for recirculating these lost nutrients but there are concerns that the sewage may not be compatible with organic standards.

The *BioForum* group in Belgium identified green manures and grass clover leys that are “cut and carried” as potential options for building soil fertility, although this raises potential issues for no-till farmers. The group also discussed forming partnerships with neighbouring livestock farms; this would involve extending their rotation in order to produce fodder that they would exchange for manure. Increased use of no-till was also discussed.

In Estonia, the *Maheklaster* group uses a range of minerals and soil activators including sea minerals, wood ash, microbial substances and mycorrhizae to improve soil fertility. Group members also grow a range of clover grass mixtures, green manure crops and use animal manure to provide different nutrients and also employ reduced tillage farming practices to improve fertility. The group identifies a need for systematic testing and analysis and hopes to form a network with research organisations, advisers and other farmers to share knowledge and experiences.

In Hungary the *ÖMKi* group strives in the long term to increase the organic matter content of their soils in order to increase its water holding capacity. Subsoilers are used to remove compaction and help improve the infiltration to prevent waterlogging. The group uses cover crops to cover the soil surface and decrease levels of evaporation from the soil. Another management tool is to ensure permanent crop cover by undersowing a cereal with a legume like clover which can be cut after cereal harvest and then cut again the following year, keeping the land cropped throughout and avoiding any tillage. Reduced tillage (no ploughing) is employed more generally to reduce water loss from the soil. Setting up a rainfed reservoir to store water for the dryer periods to use for irrigation is one idea that the group have considered to help cope with the dry summers. However this has not been developed by any of the members yet. Only farmers producing vegetable crops irrigate their fields, the irrigation water comes from drilled wells or canals.

In Italy, members of the group *ConMarcheBio* want to increase the supply of organic matter to the soil by using manure and believe proper storage and timing of applications to be important factors. Animal manure is becoming scarcer in Italy. The use of over wintered green manure (September to April) is another way to build soil fertility but the success of this practice is dependent on the farm location, as the soil condition can be a major limiting factor in its success. Minimum tillage is a practice the group aims to use rather than ploughing but the use of the plough is still necessary for weed control in certain areas where soil moisture is higher. Members of the group use a subsoiler to reduce damage to the soil and avoid the oxidation of organic matter. Minimum tillage also has the benefit of improving the soils resilience to climate change (by reducing the risk of soil erosion from extreme precipitation events). However, the possibility to apply minimum tillage in heavy clay soils is one on the main challenges for the ConMarcheBio farmers, indicating the need for applied research.

Pests and diseases

The *Bioselena* group in Bulgaria identified as a challenge the lack of organic certified plant protection products to help control pests and diseases. This has caused farmers in the group to concoct their own compost infusions to protect their crops. The group would again like a database to help with their decision making and a more reliable forecasting tool for various pests/diseases to aid in management.

In Estonia the *Maheklaster* group uses crop rotation and tillage as their main strategy against pests and diseases but also uses drilling date in combination with biological pesticides including NeemAzal, nettle manure and other plant teas. Mulching, pest nets and mechanical removal of both pests and infected plant parts are also used.

In Hungary the *ÖMKi* group use crop rotations, drilling dates, and variety choice as the foundation of pest management. Some organically certified pesticides are used such as copper based seed dressings (for soil borne diseases), copper based sprays (e.g for rust control) and neem oil. Some green manures can be used to control nematodes and pheromone traps can also be used to monitor swarming periods for the appropriate timing of organically certified pesticide applications to control certain pests.

Overview

Solutions outlined by the groups demonstrate the types of approaches that are being taken to tackle key challenges, and as such give some indication of the current knowledge and skill base of the farmer innovation groups. Some of the solutions outlined above are based on existing knowledge of the farmers, and have often been developed through trial and error. It will be important for the OK-Net Arable project to consider farmer knowledge as it can often be ignored in top-down agricultural extension models and knowledge sharing between famers (e.g. in field/stable school processes) can encourage farmers to learn from one another.

Advisers and researchers also clearly play an important role in identifying potential solutions. Although the groups seem to have considerable experience they have identified certain areas where they have a lack of knowledge and require support. For example, weed suppressing rotations is a commonly cited topic where groups require more information. There are clear areas where existing research results could be applied, and supported by advisory materials or by exchanging experiences with other groups.

Across all groups potential solutions to key challenges were identified but technologies may not yet be available, for example the role that *mycorrhizal* fungi can play in enhancing the supply of nutrients (mentioned by *Bionet* Burgenland, *Maheklaster* in Estonia and the UK groups).This represents an area where there may be a gap between farmer demand and the ability for research to deliver. It will be important to make farmers involved in the project aware of these limitations in order to manage expectations.

There are some examples of clear demands for knowledge provision which may present opportunities for developing 'quick win' solutions. For example, farmers in Flanders rely on seasonal workers from other countries who are not able to recognise weeds and lack knowledge of appropriate weed management practices. This presents an opportunity for the production of guidelines or videos (in relevant languages) that can be provided to workers. This example also demonstrates the need to consider, and pay attention to, social elements of farming systems.

In addition there are indications of areas where additional research evidence is needed by farmers, particularly regarding cost calculations of specific options. For example, farmers in *Sjaelland*, Denmark have hired a professional adviser to calculate the benefits and costs of an organic biogas plant. The biogas plant will be used to produce energy and the digestate used as a fertiliser. The cost calculations are necessary for farmers to decide whether this is a viable solution. Low-cost and low-risk strategies, or risk-sharing options, are likely to be important.

There is potential for the project to play a role in building the confidence of the groups through sharing of expertise. It is apparent that there is an interest in knowledge exchange activities, particularly exchange visits. For example, both of the Austrian groups are experiencing problems with drought. One group, *Biokompetenzzentrum Schlägl (Upper Austria),* have been experimenting with a range of potential solutions. These solutions include: planting hedges to reduce effects of wind, a well-balanced distribution between grassland and arable land, cultivating intermediate crops as nurse crops, testing water-reduced cultivation methods, compacting the soil and cultivation of drought tolerant crops and early ripening varieties. Member of Bionet Burgenland (Lower Austria), however, have not yet managed to identify feasible solutions, perhaps due to differences in context. There is an expressed interest from both groups in knowledge-exchange on the topic of water-reducing farming practices.

Many of the groups expressed an interest in information about machinery, particularly for weed management. There is also an interest in exchanging knowledge between groups in different counties related to specific kit, technologies or practices. This could be potentially useful for prompting new ideas and innovations as techniques from one country may not have been utilised in another. For example UK farmers feel there is limited machinery development in the UK when compared to other countries. The roller crimper was mentioned by the UK group as an example of a machine that has been used in other countries and could be tested in the UK.

8 Comparison of farmer group responses with research evidence

In this section we have attempted a very brief contrasting of the result regarding main challenges identified from the review of research evidence from the OK-Net Arable experts (D 3.1) with that of the farmer groups and with other material.

Weed management

There is overlap between the farmer groups in terms of the types of weeds encountered with perennial weeds such as creeping thistle, docks and couch grass mentioned by several of the groups. The report does place an emphasis on both thistles and docks as weeds that need attention in terms of weed control innovation but offers little in the way of direct weed control solutions.

The approach to weed control is underpinned by a preventative strategy involving crop rotations, and increasingly, cover cropping, intercropping and mulches to provide permanent competition for weed species. Several farmer groups reported the use of these techniques but with a need for improved knowledge on the management and application of such techniques. These techniques require specialist equipment for termination of cover crops (e.g. roller crimper) and even for direct drilling into such crops where the termination and drilling can be reduced to a single operation. There is also a need for the development of direct in-crop weeding equipment, although there is a lot of innovation in this area with the finger weeder, weed surfer, and the combcut for example. Both the report and the farmers mention the often prohibitive cost of such equipment and the potential for cooperation between farms to help spread this cost.

One other technique that could be used is the “summer fallow” that can be employed after a ley to help reduce perennial weed numbers through successive cultivations prior to autumn cropping. False seed beds clearly have a benefit in reducing annual weeds, and this technique is mentioned by both the farmers and the technical report but in the context of increased climate unpredictability, it may prove an increasingly risky strategy. Also the technique is contradictory to the idea of permanent ground cover to protect soil illustrating potential goal conflicts between reduction of problem weeds and soil protection in the choice of techniques used.

The inclusion of leys (practiced by virtually all the farmer groups) in the rotation help to significantly reduce annual weed populations, although the ley phase is less profitable and therefore impractical for stockless arable systems, highlighting the need for cooperation with livestock farms and also for green waste markets such as biogas plants. In areas where cooperation with livestock farmers is difficult, stockless rotations can use a cut and carry approach which can confer fertility and weed suppression to other parts of the rotation from leys, in addition to the soil fertility improvements and weed management benefits of the ley itself.

There is an increased focus on conservation tillage in order to preserve soil structure and biology, making weed control strategies that involve ploughing at odds with this technique. In terms of knowledge gaps reported from the farmer groups, research and information is needed on “weed suppressive” rotations and on weed biology as this usually helps indicate more serious underlying issues e.g. compaction, of which the particular weed species is a symptom. The farmer groups could also benefit from information and research concerning timing of mechanical control and its efficacy.

Overall using a system-based approach to weed management seems to be the most suitable strategy, i.e. an approach that considers economic barriers to using specialist weeding equipment, identified by the groups and the report. As identified by the expert report, ecological weed management using a well-planned cropping system, maximising the biological and ecological processes that help benefit crops while putting weeds at a disadvantage is likely to become increasingly more important. It is likely that such a strategy needs to be developed and implemented for each individual farm but there is potential in knowledge sharing about the elements that can be employed in the strategy.

Soil fertility

The methods employed by the farmers to manage soil fertility directly come down to two strategies; Firstly the use of legumes/cover crops/green manures, and secondly the use of imported (or farm produced) fertilisers in the form of manure, slurry, compost and certified organic/mineral fertiliser. Mixed farmers face fewer challenges as they can comfortably include grass/clover leys in their rotation and have farm yard manure they can use as fertiliser. Stockless arable farmers face significant challenges as including grass/clover leys can be unprofitable and they may have limited access to animal manure and slurry.

Several farmer groups reported the desire to use sewage sludge, biogas digestate and municipal waste on their land to build fertility and close the nutrient cycle by returning nutrients exported off farm in the crops they sell. The issue here is system based and is one of regulation rather than a knowledge gap as most organic farms are unable to use these recycled products due to concerns about heavy metals and other toxins being added to the soil. For organic stockless arable farms where the availability of manure and other organic fertiliser is limited, the need for improved cropping systems that make best use of the available nutrients while preventing nutrient loss is paramount.

The farmer groups and technical report agree on this point with the farmers wanting more information and advice on legume species, cover/catch cropping, the use of green manures, and the use of reduced/no tillage in the preservation of soil fertility, or more specifically the relationship between cultivations and nitrogen loss. Reduced tillage on organic farms with its positive effects on soil biology but potentially also negative side effects on weed or pest & disease control also requires more research. One possible solution posited by the expert report is the inoculation of the soil and the addition of bio-effectors to improve soil biology and help promote crop growth and nutrient acquisition. As the report highlights, this increased focus on soil biology will require the development of suitable indicators and assessment methods for biological activity.

Rotation design utilising intercropping and undersowing with legumes as well as a better understanding of cover crops and green manures should also help arable farmers improve soil fertility.

The report does not mention the need for increased or improved soil and tissue analysis in order to inform soil fertility management strategies, but it was mentioned by the farmer groups as a useful tool and may be more widely utilised to help guide organic arable farms in soil management practices.

Pests and Diseases

The best practice identified from the expert report is the implementation of a resilient cropping system. In practice this means selecting resistant cultivars, growing a diverse range of crops (including cover cropping and intercropping) and managing crops and soil to optimise health. These measures act as a preventative strategy but the option of a curative strategy does exist through plant protection products and much research is being done to identify novel substances, particularly to replace or reduce the use of copper. The report does highlight the length of time from establishing the potential of a product for use in plant protection and bringing it to market, meaning there is unlikely to be any quick solutions.

The farmer groups who identified pests and diseases as one of their top three production challenges tend to use copper based fungicides as a tool for disease control and if concerns about the use of the products exist it therefore makes sense to develop alternatives. The report focuses on potatoes and the pathogen *Phytophthora infestans* as a target for research and this does support findings from the farmer groups, with three groups specifically mentioning late blight as an issue.

The report does not deal with the issues surrounding rust control in cereals although it argues that disease is not a major yield limiting factor for cereal production. Eight of the farmer groups mentioned rust (particularly yellow rust) as a serious problem and it would therefore seem appropriate to develop novel plant protection products (PPPs) for its control, especially given that current direct control methods rely on copper based fungicides. Given the time and expense that must go into the research and development of new PPPs it makes sense to target the crops whose yield limiting factor is pests and/or diseases. Potatoes and also oilseed rape would seem like logical crops on which to focus as yields of the crops can be severely affected by pest and disease pressure. The farmer groups surveyed don't tend to grow oilseed rape due to the threat from phytophagous insects and the lack of direct pest control available.

Innovation exists in the form of smart application tools to guide management but there would appear to be a need and desire for more information in the form of plant protection product databases that are country specific and improved forecasting tools that help warn farmers of the spatial and temporal threat from disease and pests.

There is recognition in the expert report that bottlenecks should be identified for specific regions, and that the system should be adapted to specific crops and pedo-climatic conditions. The farmer groups already use so called preventative measures by employing rotations, drilling dates, variety selection, and to a lesser extent, mulching, cover cropping and intercropping so it would seem logical that the approach should be towards novel plant protection products and decision support tools. If extra diversification of cropping can also help create a more "resilient" rotation there would also seem to be a need to develop research and information dissemination in this area. Several farmer groups mentioned the need for more information on topics such as cover cropping and intercropping though not specifically in the context of pest and disease reduction.

Specific pest problems mentioned by the groups are fairly limited with only wireworms, pollen beetle and aphids being reported as issues by more than one group.

Management strategies suggested by the technical report are generally already used by the farmer groups but one strand of management approach not alluded to is that of active habitat management at field level. Although the groups may use companion planting and wildflower strips to utilise push-pull strategies which interlink cropped and uncropped habitats there is no explicit mention of this by any of the groups and it may be an area where organic arable farmers need to improve. Another aspect of managing these ecological functions is the use of intercropping, mixed cropping and undersowing which manages biodiversity within the field and is employed by some group members but not specifically used for its role in pest control by encouraging beneficial insects. Ecological features may be present on many of the farms surveyed but again no mention is made of them or the role they play in biological control of pest species. The application of this biological control requires in-depth knowledge of pest biology which the farmers may not have.

The role of nitrogen management in the reduction in susceptibility of crops to pest damage is discussed in the technical report but not mentioned by farmers with regards to pests. The farmer groups have however acknowledged the role of crop nutrition into health and resistance to disease so the application in the context of pest control is not big step. Sources of fertiliser are mentioned by the report as important for biological control by increasing numbers of beneficials and altering mineral content of plant tissue. Interestingly the report posits that there may be a role for weeds in reducing pest damage though this is at odds with farmers desire to control weeds with more information needed on ecological control and functional agrobiodiversity.

The report highlights the lack of robust and adapted cultivars for organic farming as an issue and while the farmer groups also report this they do not specifically mention the use of robust and adapted cultivars to aid pest control.

The groups do mention the use of bioinsecticides such as zinc/sulphur or neem oil based products but this must be a last resort as some products can harm beneficials and disrupt natural ecological control. More selective products have been suggested including the use of entomopathogenic fungi and nematodes.

Finally, the report goes on to mention that for many crops grown organically pest pressure is not the yield limiting factor and this does seem to match what the farmer groups reported as most groups were far more concerned with fertility management, weed control and disease control. Oilseed rape is rarely grown organically and it may be that this crop is simply not well suited to organic production. Most of the groups choose not to include it in their rotations as there are plenty of other break crop options that can provide many more rotational benefits. Potatoes are another crop that can be badly affected by pest damage and the groups who grow this have concerns about wireworm. The report offers some options including pheromone traps for the adult click beetle and the possible use of entomopathogenic fungi in combination with Spinosad. Another interesting area of research is the use of mustard cover crops as biofumigants.

Summary

These three major challenges faced by organic farmers are all linked and interdependent on one another. General preventative management strategies involving rotation, crop diversity, and cultivar selection help balance the system making it resilient to pest and disease while helping to supress weeds and build fertility. The interactions between management strategies and the effects, both positive and negative, on the various production challenges must be researched to guide farmers to make informed and beneficial management decisions. As an example, green manures can be managed to boost soil fertility and can be beneficial for both weed and pest control but can also encourage some pests and can potentially cause weed issues if not managed correctly.

The other important point is that solutions cannot be regarded in isolation as once one yield limiting factor is overcome, another one becomes important, so for example if the nitrogen supply to cereals is managed to the point where it is no longer yield limiting this may then cause weeds (also using the nitrogen) or pests (which find it easier to feed on stretched plant cell walls) to become a greater issue.

The overall impression from the farmer group survey is that the issues are multifarious and extremely site and system specific. This may make a broad brush, generic approach difficult but there is also commonality in terms of production challenges and yield limiting factors and this may offer a way forward in coordinating a European effort between farmers, advisers and scientists to improve organic arable yields.

It is worth stating that the main challenges of weed management, soil fertility and pests/diseases have been highlighted by groups of farmers who are already part of established knowledge exchange networks and so arguably have greater access to research results, advisory support and knowledge than other farmers. This therefore suggests that these issues are also likely to be problems for the wider organic arable community. The results of these exercises also echo the results of the EIP-AGRI Focus group on organic farming which identified the top challenges affecting organic arable yields as: 1) poor soil fertility management, 2) inadequate nutrient supply, 3) insufficient weed management, 4) pest and disease pressure and 5) variety choice but it is interesting to see which issues were ranked top by the groups.

9 Analysis of farmer group's current access to information

This section of the report aims to give an overview of how farmers currently access information, based on responses to Parts 1 and 2 of the monitoring framework.

Research and advisory services

The provision of agricultural advisory services varies markedly between countries in terms of state and regional structures, the differing roles played by public and private sector services, and the range of actors involved. Information about the country specific organic advisory services was not gathered at this stage, but differences in the provision can be illustrated with two contrasting examples.

Austria has a wide range of agricultural advisory services offered by the agricultural chamber that build on vocational, secondary and adult education with close cooperation between research and development. All farmers have to be members of the chamber and as a result private organisations only play a minor role in information provision. Austria has one of the highest rates of organic farming in the EU (16.4% of all Austrian farms were certified organic in 2011, compared to an EU average of 1.3% in 2010). There are specific organic advisory services organised by the Chamber of Agriculture, as well as farmer associations and educational projects like Bionet.

In contrast, in the UK there is limited public support for agricultural advisory services with some variation between the four devolved administrations. In England (where most of the members of the UK farmer group are located), some advice on agri-environment and public goods is subsidised or fully funded by government but general business advice, marketing and agronomic advice is paid for by farmers. At the end of 2014, the organically farmed area represented 3.2% of the total utilised agricultural land area in the United Kingdom (Defra, 2015). Due to the small number of organic farmers, organic advice is mainly provided by independent consultants. Some certification bodies provide information. Members of the UK farmer innovation group highlighted the lack of information and shortage of experienced advisers with some stating that they commonly refer to online information from America or other European countries due to the lack of UK specific advice. Farmers in the UK group feel that there should be more collaboration between the conventional and organic sectors in terms of information provision.

Most of the farmer innovation groups receive information from researchers, advisers or consultants who are associated with the organisations responsible for establishing the groups. It seems that this access to information from professionals is a major incentive for participation in the groups. This is particularly the case in countries where there are limited sources of support for organic producers, for example in Estonia and Bulgaria where both *Maheklaster* and Bioselena play an important role. Members of the Estonian group mentioned a lack of advisory information due to a shortage of organic advisers in the country. Apparently the available Estonian advisers only tend to give advice about general practices, how to fulfil organic requirements and basic knowledge for beginners. The role that advisers play is also influenced by available resources, for example feedback from Italy indicates that there is a lack of effective extension services in the Marche region. Advisers from the ConMarcheBio cooperatives disseminate information about best practice and innovations to farmers but are not able to demonstrate them as there are no pilot or demonstration plots available.

All of the farmer innovation groups recognised the importance of advisers in providing support and up-to-date information. The UK group in particular indicated that expert support is valuable because it is often more time efficient and can help them to find solutions to problems quickly, rather than through trial and error. A number of groups mentioned the value of advisers who have established a long term relationship with the farmer and have an in-depth knowledge of their farming system. The more detached observer role of advisers is also considered to be useful as farmers are close to their own systems which can result in them, 'seeing what they want to see'. Advisers are also respected due to their breadth of knowledge about potential solutions to problems, and access to a range of information.

All groups expressed the need for practical information with examples and highlighted the fact that research outputs often fail to meet these needs. The group from Austria *Schlägl* said: "Availability of practical oriented knowledge is important, because there is no time to deal with research results". Members of the UK group also commented that academic documents (such as those hosted on Organic Eprints) are often too long and the information is not always user-friendly as they are written predominantly for an academic audience, the most useful elements of academic papers for members of the groups are the summary, conclusion and references. Members of the Estonian group also mentioned the need for scientific articles to be 'translated' into practical language. Generally there is a sense that research knowledge is not always made available in accessible formats for farmers, and advisers, although it is not always clear what is meant by this. Also, there is sense from some groups that research results can sometimes conflict with each other which can lead to confusion.

Farmer-to-farmer

Knowledge exchange is a key aim of many of the groups; however, it is not clear to what extent the farmers would engage in knowledge exchange activities without the groups. This suggests that facilitation is an important aspect for encouraging farmer-to-farmer knowledge sharing. However, it is also important to acknowledge that the degree to which farmers are willing to share information may be influenced by a number of factors, such as the extent to which they are in competition with one another, whether there are clear incentives for knowledge exchange, the dynamics of the group and how well the members know each other as well as other social and cultural factors etc.

Overall all of the groups expressed an interest in accessing knowledge from other farmers, information from other farmers was also seen as the most reliable, trustworthy source of information. All groups articulated a strong preference for information sharing through practical demonstration and farmer-to-farmer experience sharing through exchange visits. Farmers in the UK reported a sense of isolation and welcomed opportunities for meeting with other 'like-minded' farmers. Members of all groups are reportedly influenced by neighbouring farmers, for example in Italy if farmers encounter a problem their first port of call is likely to be a neighbouring farmer. This indicates that neighbouring farmers are likely to be a significant channel of influence, particularly in relation to problem solving and potentially also influential in terms of technology adoption.

It is clear that farmers involved in the groups have valuable experience and knowledge, but it is likely to be based on knowledge of their specific farm environment and the challenges they face and therefore is likely to be context specific. There are questions about how this knowledge can be shared with others in order to short cut learning curves, and the extent to which this knowledge is relevant and meaningful to other farmers working in a different farming context. There may be scope for developing methods for evaluating knowledge based on its relevance, usefulness and applicability.

Farmer groups/networks
Generally most of the farmer innovation groups seem to have relatively limited contacts with other farmer groups or networks outside their immediate group. For example, in Hungary workshops that bring farmer groups together are quite rare. In Italy it was noted that farmers are not familiar with the concept of a ‘farmer group’, despite being involved in a cooperative, and tend to be quite individualistic in nature. However, some groups which are part of larger established networks do participate in farmer-to-farmer experience sharing activities, including exchanges between countries, for example the BASE network which has organised exchanges between farmers in France and the UK. This process seems to be facilitated/organised by the group facilitators or coordinators rather than initiated by farmers themselves. This again highlights the important role that facilitators can play in encouraging interactions.

Information exchange and experience sharing can be important catalysts for innovation. It seems there is a keen interest on the part of the farmer innovation groups to meet farmer groups from other parts of Europe in order to share experiences. There seems to be an interest in doing this face-to-face as well as online. This perhaps presents an opportunity for the development of ‘blended learning’ approaches that combine online and offline exchanges. The topics for knowledge sharing should be led by farmers themselves and by their interests and priority challenges. A danger of top-down innovation projects is that they are usually designed and led by researchers, this element of control can potentially constrain the innovation process.

Online tools
Overall there seems to be fairly limited use of online tools and social media channels by members of the groups. It is frequently mentioned that online tools tend to be used by younger members, e.g. in Hungary and Italy. Some online tools were mentioned, for example farmers from BASE-ABC France use a forum called ‘Agricool’. Farmers using online marketing e.g. ‘web shop’ in Austria Burgenland, but the use of online sales seems to be very rare among the groups. It is apparent that farmers’ use the internet to access information, but specific sites were not always specified. Ministry websites are an important source of information in Germany. Farmers in Estonia use the organic farming portal Maheklubi.ee.

Results from the online survey (part 3 of the monitoring framework) indicate that videos via YouTube are a popular medium for accessing information. More research is required to understand why this medium is so popular, possibly due to its ability to convey tacit/practical knowledge more effectively than other formats. There also needs to be more understanding of what kinds of information farmers gain from videos, and whether video can be combined with other information formats for more effective dissemination/learning.

There was not much mention of social media or forums, although farmers in the UK mentioned ‘The Farming Forum’ and a Twitter stream called ‘Agrichat’ as important sources of information. Overall members of the groups do not seem to be very receptive to social media. An element of capacity building may be required to enable groups to utilise online platforms.

Despite the limited use of online information there does seem to be an interest in using online tools. The need for an up-to-date knowledge database was expressed by a number of groups. For example, the Bioselena Bulgaria group state that they currently use the internet to access information but that there is a lack of practical, up-to-date advice. The Estonian and Hungarian groups also mentioned that although their farmers look for solutions on the internet there is limited information available in relevant languages.

Printed and other information sources
Printed materials, namely newspapers and magazines, are mentioned as an important source of information. Cited examples include a farmer magazine called Bioszene in Germany, Biopraktijk newsletter in Flanders, the Organic Research Centre Bulletin and Farmers Weekly newspaper in the UK, and a quarterly Organic Farming newsletter in Estonia. Professional journals and specialist literature are also relevant sources of information. Farmers also reportedly listen to radio programmes with an agricultural focus, such as BBC Farming Today in the UK. Another important source of information is agricultural fairs, markets and events.

Important factors for effective information sharing

Practical demonstration
Farmers stress that practical experience and physical demonstrations are important ways of learning. For example, practical examples of farmers who have successfully implemented specific practices help to demonstrate that practices can work in real farming contexts, rather than in trials or as theoretical ideas. This raises interesting issues for the project, i.e. to what extent can practical knowledge be shared via online platforms.

Time
Time is a significant factor in terms of information provision, farmers clearly express the need for information that can be consumed quickly and easily. More than one group mentioned ‘information overload’ being a problem. Searching for relevant information is time consuming for both farmers and advisers. It can be challenging to sift through available information to find material that is trustworthy, practically oriented and presented in accessible formats. The project will need to consider the extent to which current information meets these demands, and whether information included on the knowledge platform needs to be re-designed or presented differently.

Context specific information
Responsiveness to farmer demand will be a key consideration in terms of the effectiveness of an online knowledge platform – i.e. how to provide for and respond to the diversity of context specific needs of farmers (e.g. variations of farm size, variations in crop production and management practices etc.). Certain groups also expressed a need for region specific information, for example Austrian farmers seem very keen to learn from other Austrian farmers and the German network identified a need for regional information, presumably because of the size of the network and the variability of regions in the country.

Reliability
Overall there seems to be a concern that information or advice should be independent and trustworthy. Across the various countries, information is often provided by the private sector (e.g. suppliers of farming inputs) but farmers are aware that this information may be biased. In Italy farmers stated that technical support should be provided by the regional agricultural agencies as they are perhaps regarded as more reliable. An important function of farmer groups, such as those participating in the OK-Net Arable project, is that they are often established by recognised

institutions and enable the building of relationships based on trust and reciprocity. Learning from other farmers is also an important factor in terms of reliability; knowledge based on practice is often regarded as being more trustworthy. It is worth considering how online methods can demonstrate the reliability and authenticity of information as trust is an important factor in terms of uptake and adoption of new methods, practices and approaches.

10 Potential for innovation

Members of the farmer groups are demonstrating a proactive and dynamic approach to their farming systems and are continually observing and experimenting in response to their environment as well as external factors. This has resulted in a number of specific innovations that were mentioned by the groups including the production of special 'threshing crops' (fennel, cumin and coriander) in Austria *Schlägl*; new fertilisation strategies were mentioned by members of the Bioforum group in Belgium; members of the SEGES Sjaelland group are exploring the development of a biogas plant in response to issues with nutrient supply; members of BASE-ABC in France are experimenting with a number of innovations to support the sustainability of arable cropping systems (e.g. sowing soya seed directly on a cover of rye and beans, testing a 'brewery spent grain fertilizer, experimenting with simultaneous grain harvesting). Exchanges between farmers and advisers, and literature monitoring, have been important elements in the innovation process for the BASE network. Long term experiments are co-designed by farmers and advisers, and farmers are able to draw on their own experiences in the design of innovative systems. There is potential for the results of these experiments, as well as the process, to be shared with other farmers and advisers beyond the BASE network.

There are likely to be numerous other 'innovations' by the groups, but when prompted by questions in the framework a limited number of 'innovations' were reported. This could be due to different understandings of the term on the part of researchers and farmers, or reluctance on the part of farmers to describe their practices as 'innovations'. There is certainly scope for further innovation, particularly in terms of increased interactions between farmer knowledge and scientific research results, farmer-to-farmer collaborations such as arrangements between arable and livestock producers, exchanges between experienced farmers and new entrants that build on different expertise. Different marketing channels are being used by the groups and there may be scope for innovation in terms of expanding these channels through the development of online marketing tools. A range of specialist equipment is being used by the groups; information could be shared between groups with the view to identifying appropriate equipment for different contexts and highlighting potential adaptations that could be made. Systems for exchanging machinery were also suggested by farmers in Germany as a solution to high equipment costs. Members of the SEGES Videbaek group in Denmark are involved in initiatives for obtaining specific hoeing machinery and a couch grass remover on demonstration which highlights the benefits of collaboration.

In many cases the groups have already taken innovative steps to addressing challenges, but are sometimes blocked by factors beyond their control, for example by regulations or changing environmental conditions. For example, in Italy farmers face problems with limited seed availability. As a solution to this problem some farmers save seed for use the following season, and in some cooperatives farmers save seed for the whole group. However, these strategies are restricted due to issues with legal authorisation of seed. Although it is possible for these farmers to establish themselves as a "seed company" there are high investment costs which prohibit the uptake of this option. These represent bottlenecks that may not be addressed by a purely technical solution but require either collective action or input from other actors within the system, and in many case involves addressing institutional or social issues. These types of problems (sometimes referred to as 'wicked problems') may be beyond the scope of what the OK-Net Arable project can address.

11 Concluding remarks for the next stages of the OK-Net Arable project

Differences between groups and within groups clearly indicate the potential for improvements in agronomic practices through knowledge exchange. As such it will be important for the results of this report to be considered in the next phases of the OK-Net Arable project, particularly in terms of the prioritisation and selection of tools to be tested by the farmer groups and shared via the knowledge platform.

Addressing farmer priority challenges

Facilitators of the farmer innovation groups indicated that farmers are expecting concrete results from the project, specifically regarding solutions to the challenges that they have identified. This is a clear incentive for farmer participation in the project and interest is likely to decline if these expectations are not met. The project should therefore ensure that farmer needs are prioritised by ensuring that the tools selected for testing are relevant to the challenges faced by the farmer groups. It is likely that a range of tools will need to be offered that are relevant to different contexts, and which can be used by farmers with different levels of experience, knowledge and skill. Below are some general suggestions for tools to address challenges identified by the groups involved in the project:

Weed management

- Tools that enable farmers to design/plan weed suppressing rotations;
- Tools that provide information about intercropping options;
- Tools that provide information about common weeds (e.g. docks, thistles, couch, fat hen, wild oats);
- Tools that provide information about mechanical/physical weed control options.

Soil fertility

- Tools to effectively design and manage rotations for maximum fertility;
- Tools that provide information about off-farm inputs, when to apply them and how to source them;
- Tools that provide information about cultivation techniques to maintain fertility;
- Tools that provide information about measuring soil fertility using soil and plant tissue analysis.

Pests and disease

- Tools that provide information about organic crop protection methods;
- Tools that provide information about common diseases (e.g. rusts, late blight and mildew;
- Tools that provide information about commonly reported pests (e.g. pollen beetles (*Meligethes spp*), wireworm (*Agriotes spp*.) and aphids (*Aphidoidea spp*.);
- Decision making tools with recommendations for dealing with specific pests/diseases;
- Forecasting tools for pests/diseases.

System design/decision making

- Tools that assist farmers to take a systems perspective;
- Tool that help farmers to manage conflicting goals within the farming system (e.g. weed control – soil fertility etc).

Linking farmer and researcher perspectives
There are clear linkages between results from the farmer innovation groups (contained in this report) and information contained in the WP3 report 'D3.1: State-of-the-art research results and best practices', as well as with the results of EIP Focus group report. However, as these reports have been written in parallel further work may be required to synthesise the results in order to develop clear recommendations. The D3.1 report highlights a number of tools that have potential to address challenges indicated by the farmer groups; however the final selection of tools for evaluation and testing should be led by the groups themselves based on their interest and the relevance of the tools to their farming context. The testing stage of the project will be important in determining whether the tools identified by researchers respond to farmer needs and communicate relevant information effectively to a farming audience. It will also be crucial to identify the tools that the farmer groups find useful in order to understand the elements that could contribute to the development of future successful knowledge exchange materials.

Successful examples
The results of the monitoring framework identified limited suggestions from the farmer groups regarding successful tools that they already use. It would be useful to gather more information from the groups regarding what they consider to be useful knowledge exchange tools, both in terms of the information communicated and the format used to convey this information. It may be possible to identify certain patterns or preferences that can be used to design effective knowledge exchange tools in the future. For example, the information gathered from the farmer groups indicates that video is considered to be a particularly useful format for sharing information about equipment.

Common understanding of project aims
Conversations with the farmer innovation groups indicate that it may be necessary to develop a clearer common understanding of the project aims between the various actors involved in the project. It is clear that the main aim of the project is to improve the exchange of knowledge, initially by facilitating exchanges between the farmer groups and then at a larger scale via an online knowledge portal. As such it is likely that there is limited scope for practical testing, field trials etc.

Another core aim of the project is to develop and test innovative practical and educational materials, also referred to as 'tools'. However there may be differences in understanding between farmers and researchers regarding 'tools'. For example, some groups mentioned the need for sensors, cameras and mechanical devices which are likely to be beyond the reach of what the project can achieve. However, they also mentioned the development of apps and calculators etc. which may be more achievable. It would be helpful for the project to develop clear parameters for the types of 'tools' that are to be developed and tested.

There may also be a need to determine whether the project is focusing on sharing existing knowledge or on catalysing new innovation, this will have an influence on the direction and emphasis of the next phase of the project. It is clear that there is much potential in terms of gaining a better understanding of the information needs of farmers, and what methods work best for sharing knowledge effectively, which may help to catalyse innovation in the longer term.

Farmer-to-farmer knowledge sharing
There is a demand among the farmer groups for farmer-to-farmer knowledge sharing, and there is potential to facilitate this knowledge sharing around key topics, i.e. the main challenges identified by the groups. The options for facilitating group exchanges both online and offline should be explored.

This could include the establishment of thematic sub-groups focusing on soil fertility, weed management, pest and disease control etc. These groups could be used to develop an integrated or 'blended' approach between offline and online knowledge exchange methods that would be beneficial for the sharing of knowledge on a larger scale. It will be essential to ensure that any online knowledge sharing methods utilised by or developed by the project are easy to use and accessible. The project may need to consider options for capacity development for participating farmers.

12 References

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13 Appendix

	Group	AT1	AT2	BE	BG	DK1	DK2	DK3	EE	FR1	FR2	DE	HU	IT	UK
	Climate	Continental	Alpine	Northern temperate	Continental / Mediterranean	Northern temperate	Northern temperate	Northern temperate	Northern temperate	Northern temperate	Northern temperate / Mediterranean	Northern temperate	Continental	Continental	Northern temperate
Rainfall/mm		300-900(600)	300-900(600)	700	300-847	500-700(600)	750-900	?	-646	600-1100	629-905	550-730(676)	450-800	?	560-850
Altitude/m		Below 300m - 600m	Below 300m - 600m	Below 300m	Below 300m - Above 600m	Below 300m	Below 300m	Below 300m	Below 300m	Below 300m - Above 600m	Below 300m	?	Below 300m	Below 300m - 600m	Below 300m
Most limiting climatic factor															
Cold long winter			x						x						
Too high precipitation in springtime						x		x		x	x	x			
Too high precipitation in autumn						x				x	x	x		x	
Too dry summer		x			x					x	x	x	x		
Other		Dry zone: Water and temperature – (over 30 degrees), dry spring, dry early summer	Average annual temp too low	Short/wet summer	irregular rainfall		growing season too short		Highly variable/unpredictable - too much/little rain					Cold spring	

Table 1. Climatic zones, altitude, rainfall, and limiting production factors

Group		AT1	AT2	BE	BG	DK1	DK2	DK3	EE	FR1	FR2	DE	HU	IT	UK	Overall
Crops																
Wheat	9	2.5 - 5		4-6	0.3-8	2-3			1.5-4.5	1-4 (3)	2-3.5		3-5		3-6	0.3-8
Barley	10	2-4	1.5-5	5-9	1-3.5	3.5-4.5	3.5-6.5	x		1-4 (3)	2-3.5			1.5-4	3-4.5	1-9
Triticale	6		3-6	5-9	2.4-3.9			x		1-4 (3)	2-3.5				2.5-4	1-9
Rye	5		2-4		1.2-3.5	4-5	3.5-6.5	x	1.8-3.6							1.2-6.5
Spelt	4				0.8-3								2.5-5	1.5-3.5	3.5	0.8-5.5
Oats	3						3.5-6.5		1.6-3.5						2.5-5	1.6-6.5
Durum whe	1													1.5-4.5		1.5-4.5
Millet	1				0.8-2											
Peas	6				2.5-3.5	3.5	3-4.5	x	1.8-3.2		1-4				3	1-4.5
Faba Beans	8		1.5-4		0.5-1.2	3.5-5	3-4.5	x	1.8-2.5	2.5-3	1-4			1.5-2.7	2.5-4.5	0.5-5
Soya bean	4	1.5 – 3.5								2-4	1-4		0.5-2.5			0.5-4
Chickpea	1													0.8-2.5		0.8-2.5
Lentils	1									1.5						
Maize	6	4-8	10-15		0.8-2.5					4.5-14 (9)	8-10		3-6			3-15
Sunflower	2	2-3											1-3			2-3
Oilseed rap	1					2-3										
Grass/clove	4		5-9	7-12						6-10					8-10	5-12
Lucerne	5		5-8		0.5-0.75					1.5			4-5	4.5-15		0.5-15

Table 2. Crop yields (t/ha)

			AT1	AT2	BE	BG	DK1	DK2	DK3	EE	FR1	FR2	DE	HU	IT	UK
Challenge 1			Soil fertility	Nutrient cycle	Soil with focus on fertilisation	Pests & disease	Fertiliser	Weeds	Management	Soil fertility	Nitrogen management	Weed management	Nutrient supply	Weed management	Mechanisation (Weed control/ploughing)	Weeds
Challenge 2			Nutrient cycle	Weed management	Diseaeas & pests	Lack of knowledge, experience and information	Rotations involving clover grass	Minerals	Minerals	Weed control	Weed management	Nitrogen management	Crop rotation	Pest management	Seed availability	Soil fertility
Challenge 3			Climate change	Adaption to climate change (3)	Weeds	Weed control	Economics	Management for weeding	Weeds	Pests & disease	Organic breeding/varieties	Biodiversity	Disease & weed management	Soil-Water management	Soil fertility and fertilisation	Yield, tillage, lack of
	Mention	No 1														
Weeds	11	4		2	3	3		1	3	2	2	1	3	1		1
Pests & diseases	5	1			2	1				3			3	2		
Soil fertility	8	4	1		1			2	2	1			1		3	2
Nitrogen	2	1									1	2				
Cultivation	2	1													1	3
Yield	1	0														3
Seeds	1	0													2	
Lack of knowledge/research	3	2				1			1							3
Biodiversity	1	0										3				
Soil water	1	0												3		
Nutrient cycle	2	1	2	1												
Adaption to climate change (3)	2	0	3	3												
Weeding equpment	1	0						3								
Fertiliser	1	1					1									
Economics	1	0					3									
Rotation (clover grass)	2	0					2						2			
Organic varieties	1	0									3					

Table 3. Top three challenges faced by each group.