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# Organic Agriculture

## Exchanging knowledge to improve organic arable farming: An evaluation of knowledge exchange tools with farmer groups across Europe --Manuscript Draft--

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<b>Abstract:</b>	<p>Organic farming is knowledge intensive. To support farmers in improve yields and organic agriculture systems, there is a need to improve how knowledge is shared. There is an established culture of sharing ideas, successes and failures in farming. The internet and information technologies open-up new opportunities for knowledge exchange involving farmers, researchers, advisors and other practitioners. The OK-Net Arable brought together practitioners from regional Farmer Innovation Groups across Europe in a multi-actor project to explore how online knowledge exchange could be improved. Feedback from the groups was obtained for 36 'tools', defined as end-user materials, such as technical guides, videos on websites informing about practices in organic agriculture. The groups also selected one practice to test on farms, sharing their experiences with others through workshops, exchange visits and through videos. Farmers valued the same key elements in face-to-face exchanges (workshops and visits) as in online materials. These were the opportunity for visual observation, deeper understanding of the context in which a practice was being tried and details about what worked and what did not work. Videos, decision support tools and social media can provide useful mechanisms for taking knowledge exchange online, if farmers' experiences and practical implication are shared, and more visual information about the context, economics, successes and failures is provided. Online platforms and forums should not be expected to replace but rather to complement face to face knowledge exchange in improving organic farming.</p>	

# 1 **Exchanging knowledge to improve organic arable farming: An evaluation of** 2 **knowledge exchange tools with farmer groups across Europe**

## 3 **Abstract**

4 Organic farming is knowledge intensive. To support farmers in improve yields and organic agriculture  
5 systems, there is a need to improve how knowledge is shared. There is an established culture of  
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20 but rather to complement face to face knowledge exchange in improving organic farming.

21 **Keywords:** Knowledge exchange, internet, peer-to-peer, video, technical guide, organic arable  
22 farming

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41

# 42 Exchange knowledge to improve organic arable farming: An evaluation of 43 knowledge exchange tools with farm innovation groups across Europe

## 44 1 INTRODUCTION

45 The global literature for temperate and Mediterranean climate zones narrows the yield gap between  
46 organic and conventional farms down to 9 to 25 percent (Seufert et al., 2012; De Ponti et al., 2012),  
47 with legumes showing a considerably smaller yield gap than cereals or tubers (Roös et al., 2018).  
48 There is now a re-vitalized interest in increasing yields in organic agriculture to provide more organic  
49 food for a growing population. Yield differences within organic farming are a starting point for  
50 potential yield improvements but are less well documented. Yields vary considerably with growing  
51 conditions, management practices and crop types. According to Roös et al. (2018) much can be  
52 gained from better management on farms that substantially underperform in comparison with top-  
53 performing farms under the same conditions.

54 The Organic Knowledge Network Arable (OK-Net Arable), a three-year thematic network funded  
55 under Horizon 2020 aimed to improve knowledge exchange (KE) between farmers, advisors and  
56 scientists and thus to improve organic arable production throughout Europe. It was founded in the  
57 belief that there is potential for improving agronomic practices through KE on best and innovative  
58 practices, which could help to bridge the yield gap between organic and conventional, as well as  
59 among organic, farmers. Cullen et al. (2016) reported on yield differences between different organic  
60 farmers in innovation groups that took part in the OK-Net Arable project. For example, for winter  
61 wheat, the reported variation in yields ranged from 0.3 to 8 t ha<sup>-1</sup>, with the majority of groups  
62 reporting yields ranges from 1 to 6 t ha<sup>-1</sup> (Cullen et al., 2016). Similarly, long term trends on five  
63 organic farms for organic winter wheat yield in the UK show a range of 2.4 to 6.9 t ha<sup>-1</sup> (Calbeck and  
64 Sumption, 2016). All these data suggest a need to improve yield performance and stability in organic  
65 farming. Niggli et al. (2016) describe a number of practices for organic arable cropping that could  
66 help to improve yields. This involves the implementation of well-known best practices, e.g. the use  
67 of favourable crop rotation design to prevent weed infestation and disease and pest outbreaks, but  
68 also the sharing of less-known practices and innovation (e.g. bio-effectors, robotics). The OK- Net  
69 Arable project contributes directly to key features of Organic 3.0 of continuous improvement  
70 towards best practice, of using the internet and social media, of empowering as well as  
71 systematically extracting, evaluating, preserving and renewing tacit knowledge of farmers and farm  
72 communities (Arbenz et al., 2017).

73 Innovation is closely related to information flows, learning and social interaction and different types  
74 of knowledge can play important roles in social learning (Knickel et al., 2009). A focus on innovation  
75 processes rather than singular innovative ideas is typical of transition theory, recently used to look at  
76 innovation for sustainability in European agriculture. This recognises the importance of improving  
77 the flow of information from scientists to farmers and advisors in supporting farmers to make better  
78 decisions (Pretty et al., 2010). With this goes a need to rethink communication in agriculture –  
79 moving away from the idea of a linear ‘transfer of technology’ from research to practice to  
80 supporting knowledge exchange between all actors in an innovation system, including researchers,  
81 farmers and advisors (Leeuwis and Aarts, 2011). This interactive model of innovation underpins the

82 European Innovation Platform for Agriculture, EIP-AGRI<sup>1</sup>. One the instruments of EIP-AGRI are the  
83 thematic network projects for agriculture in H2020, such as OK-Net Arable.

84 Despite the clear benefits of face-to-face KE and n field events, these are costly in time and travel. It  
85 is therefore interesting to consider how KE can be taken online. The internet offers a huge  
86 opportunity to enhance KE on sustainable farming. Information can be made rapidly available,  
87 updated regularly and shared with a wide audience. Offering the opportunity for more interaction  
88 between users. However, there is also a danger of information deluge and it is therefore essential to  
89 consider how providing access to relevant and reliable information can be ensured (Bruce, 2016).  
90 Information sources aimed at the farming community are often fragmented and disconnected  
91 (Klerkx and Proctor, 2013), as such there is a need to pull them together in one place for busy  
92 farmers to find information and online hubs can play a key role (Bruce, 2016).

93 In the Organic Knowledge Network Arable (OK-Net Arable) we adopted an interactive multi-actor,  
94 co-innovation approach, based on collaboration of organic research institutes, organic farming  
95 associations and a network of regional Farmer Innovation Groups across ten countries (Austria,  
96 Belgium, Bulgaria, Denmark, Estonia, France, Germany, Hungary, Italy and the UK). These groups  
97 included organic farmers who grow arable crops, advisors and researchers and they meet regularly –  
98 at least once per year. The thematic network thus aimed to realise co-innovation processes that  
99 bring together a range of actors, including researchers and advisors, to create space for change  
100 (Leeuwis and Aarts, 2011).

101 The project looked at the research communication process from a farmer’s perspective. A  
102 Knowledge Exchange (KE) tool was defined as formatted information used as a means for the  
103 circulation of knowledge among farmers and advisors, potentially involving (as source of  
104 information, a reference or other, but not as primary target) researchers (Ortolani and Micheloni,  
105 2016). The project partners identified KE tools on organic arable crops topics in the form of technical  
106 guides, decision support tools, websites and videos and presented them on a newly developed  
107 knowledge platform ([www.farmknowledge.org](http://www.farmknowledge.org) .)

108 We worked with the Farmer Innovation Groups to improve their access to practical knowledge, but  
109 also to learn about their challenges and likes and dislikes of different types of KE tools that are  
110 available online. Common challenges identified by the groups related to weed management, soil  
111 fertility and pest and disease control, but they also made reference to a general lack of knowledge  
112 and research about organic agriculture; nutrient management, especially nitrogen; and challenges  
113 with grass clover leys and rotations (see Cullen et al., 2016). Each group was then asked to provide  
114 feedback on relevant KE tools through workshops and by using some of the practices, equipment or  
115 recommendations described in the tools.

116 This paper sets out key feedback on KE tools and the process of co-evaluation. . It then seeks to draw  
117 on these learnings for improving online KE on organic farming.

## 118 **2 METHODOLOGY**

119 The approach used in the OK-Net Arable project to evaluate Knowledge Exchange (KE) tools with  
120 Farmer Innovation Groups was based on an initial offer of tools for groups to choose from and then

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<sup>1</sup>[https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri\\_brochure\\_multi-actor\\_projects\\_2017\\_en\\_web.pdf](https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_brochure_multi-actor_projects_2017_en_web.pdf)

121 discussing them in moderated structured workshops, supported by some scoring exercises and use  
122 of some of the tool recommendations. The tool evaluation considered the thematic fit, i.e. whether  
123 a tool provided a useful answer to the challenge that the groups were facing and the preferences of  
124 the Farmer Innovation Groups for different types or formats of the tools.

125 An initial offer of 30 tools describing practices in organic agriculture, divided into five themes, was  
126 selected by the project steering group (see Table 1) based on a list of criteria that included type of  
127 tool, provision of practical information, availability in English and other languages, potential for  
128 translation and wider geographical relevance. Each group was encouraged to select up to ten tools  
129 from this initial offer but could also make suggestions for different tools (for example in their own  
130 language), which were then added to the offer. The tool evaluation presented in this paper is based  
131 on 43 different tools, which included different types of leaflets/technical guides, decision support  
132 tools, websites and videos (see Table 2). Of those, 36 tools were evaluated by one or several of the  
133 Farmer Innovation Groups in workshops. Most tools have been uploaded to the knowledge platform  
134 of OK-Net Arable ([www.farmknowledge.org](http://www.farmknowledge.org)), but some have been reclassified under different topics  
135 or tool type after they have been evaluated by the farmers group.

136 The network was made up 12 Farmer Innovation Groups in ten countries, with approx. 343 organic  
137 farmers and advisors engaged in total, group sizes varying from 8 -49. All members of Farmer  
138 Innovation Groups grow organic arable crops and cereals but represent a range of farm types,  
139 including cereal producers, mixed farms with livestock, farms with field vegetables (e.g. potatoes,  
140 cabbage, leeks etc.) and horticultural farms, as well as stockless arable cropping systems. Farm sizes  
141 ranged from 0.5 ha in Hungary to 1 110 ha in Estonia and varied markedly within the groups, for  
142 example 17 ha to 300 ha in Denmark Sjaelland (Cullen, et al., 2016). Each Farmer Innovation Group  
143 held two workshops to conduct qualitative evaluations of the KE tools, with a total of 22 workshops  
144 in 2015/16. In the first workshop each group discussed 5-7 tools and provided feedback. The groups  
145 also scored these tools on a five-point scale (1 = low, 5 = high) for relevance (how appropriate the  
146 topic of the tool was to their priorities, challenges and conditions on farm), interest (how engaged  
147 the participants were with the topic of the tool), ease of use (how user friendly and simple they  
148 found the tool to use) and practicality (how easily the participants felt the information could be  
149 transferred into practice). An average of these scores was calculated. This analysis was  
150 complimented with qualitative data from workshop discussions. In total, 53 separate tool scores  
151 were reported by groups for 33 tools<sup>2</sup>. Most groups used face-to-face workshops, but two groups  
152 conducted this step by phone. Each group then selected three tools for a more detailed qualitative  
153 assessment in a second workshop, to get a deeper understanding of the strengths and weaknesses  
154 of each tool. The results presented here are based on a synthesis of the qualitative feedback on each  
155 tool from all groups, which enabled key themes and critical success factors to be identified (see also  
156 Bliss et al., 2018). The names of the groups have been replaced with a letter (from A to L) to protect  
157 the anonymity of the comments.

158 In a final step, each group could select one tool to implement and evaluate in practice. This step was  
159 designed to give farmers the opportunity to do something practical and groups were free to choose  
160 a topic that was of interested to them. In total 11 trials were carried out, related to mainly to weed  
161 control, soil fertility and nutrient management tools. Six trials related to the use of machinery that  
162 was previously not used in the region or country, such as testing the roller crimper for terminating  
163 cover crops, testing of weed control equipment and an equal spacing seeder and one trial looked at

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<sup>2</sup> 3 tools were evaluated in discussions, but no scores were provided, which explains the difference between the total numbers evaluated and the scores.

164 cultivars for cover crops. Four tested tools for diagnose of soils and rotation, such as the [Spade Test –](#)  
165 leaflet and using the nutrient dynamics model [NDICEA](#) on several farms. The process of practical tool  
166 testing in the field was documented with video diaries, which were edited into short videos shared  
167 on a ‘farm news’ page on the knowledge platform of the project [www.farmknowledge.org](http://www.farmknowledge.org). This online  
168 hub developed by the project brings together existing and new KE tools developed or translated in  
169 the OK-Net Arable project, including practice abstracts.

170 A series of exchange visits further enabled Farmer Innovation Groups to share experiences and  
171 knowledge on key topics of mutual interest, including intercropping and organic no till. A co-  
172 innovation workshop in Valence (France) in September 2017 enabled representatives of the groups  
173 to come together to share what they had learned and discuss emerging questions, with peers from  
174 other countries acting as ‘advisors’. Feedback and reflections from these meetings, exchange visits  
175 and workshops were also documented (see Gócs et al, 2018) and provided additional insight into  
176 farmer perceptions and preferences for KE and the experience of being engaged in the Farmer  
177 Innovation Groups.

178 In the following section on results, we present the preference and feedback for tools covering the  
179 different topics and the feedback and preferences for different tool types. Preferences have been  
180 derived from the first choice (which tools were chosen to be evaluated by the groups) and the  
181 average scores for the tools, which give a qualitative indication complementing the feedback from  
182 the discussions with the group members that were reported. This is followed by a section on  
183 common themes that emerged from the feedback, which is largely descriptive, using quotes from  
184 the groups to illustrate points that the group have made. It should be also noted that the majority of  
185 the tools evaluated are in English, which may have influenced the results, although some groups  
186 chose to provide feedback on similar tools in their own language.

## 187 **3 RESULTS**

### 188 **3.1 Preferences for topics**

189 We presented the Farmer Innovation Groups with an initial offer of 30 tools, categorised in five  
190 thematic areas. Table 1 shows the number of tools that were chosen for evaluation in each theme.  
191 The average scores (Figure 1) indicate that in each topic, tools received lower average scores for  
192 ‘practical’ than for ‘interest’ or ‘relevance’.

193 The highest number of tools evaluated by groups related to **soil quality and fertility** and similar  
194 topics, which was also identified as an important challenge by the groups (Cullen et al., 2016). The  
195 initial offer included many technical guides for visual soil assessment and earthworm activity and  
196 how to grow green manures to improve soil structure. The groups added three tools covering similar  
197 topics in their own language.

198 There was considerable thematic overlap of **soil quality and fertility** with **nutrient management**  
199 related tools; for example, tools related to green manure use were represented in both themes.  
200 Apart from technical guides, nutrient management also included websites and decision support (also  
201 called calculator) tools. One of the website tools, [Cover crop and living mulch tool box](#), was  
202 evaluated by seven groups. The tool was well liked on first impression, further confirmed during  
203 workshop discussions.

204 **Table 1: Number of tools selected and evaluated by theme**

Theme	Initial offer	of which evaluated	New tools suggested by groups	Total number of tools considered	Of which evaluated
<b>Weed management</b>	6	5	3	9	8
<b>Soil quality &amp; fertility</b>	6	6	3	9	9
<b>Pest &amp; disease control</b>	6	1	1	7	2
<b>Nutrient management</b>	6	5	2	8	8
<b>Cropping systems &amp; crop specific</b>	6	4	4	10	8
<b>Total</b>	<b>30</b>	<b>21</b>	<b>12</b>	<b>43</b>	<b>35</b>

205 Source: Own data

206 Taking both topics together, the tools found most relevant were relating to green manure/cover  
207 crops, visual soil assessment and building soil carbon. Tools on nutrient management were  
208 considered relevant but were not liked overall and may not have been meeting the farmers' needs.

209 **Weed management** tools were also popular, which corresponds well with the importance of weed  
210 control as a challenge for most of the Farmer Innovation Groups (see Cullen et al., 2016). This  
211 category included several videos, mostly related to reduced tillage. Tools on mechanical weed  
212 control received high scores, in particular those comparing different machinery, but the farmers also  
213 commented that such information goes out of date quickly with new developments. The feedback  
214 indicated that the groups would like to see some tools that provide information on weed biology and  
215 lifecycles to support improved management. Moreover, it was clear that more tools should focus on  
216 an integrated approach to weed control, which includes preventative and cultural control as well as  
217 direct methods such as mechanical weed control.

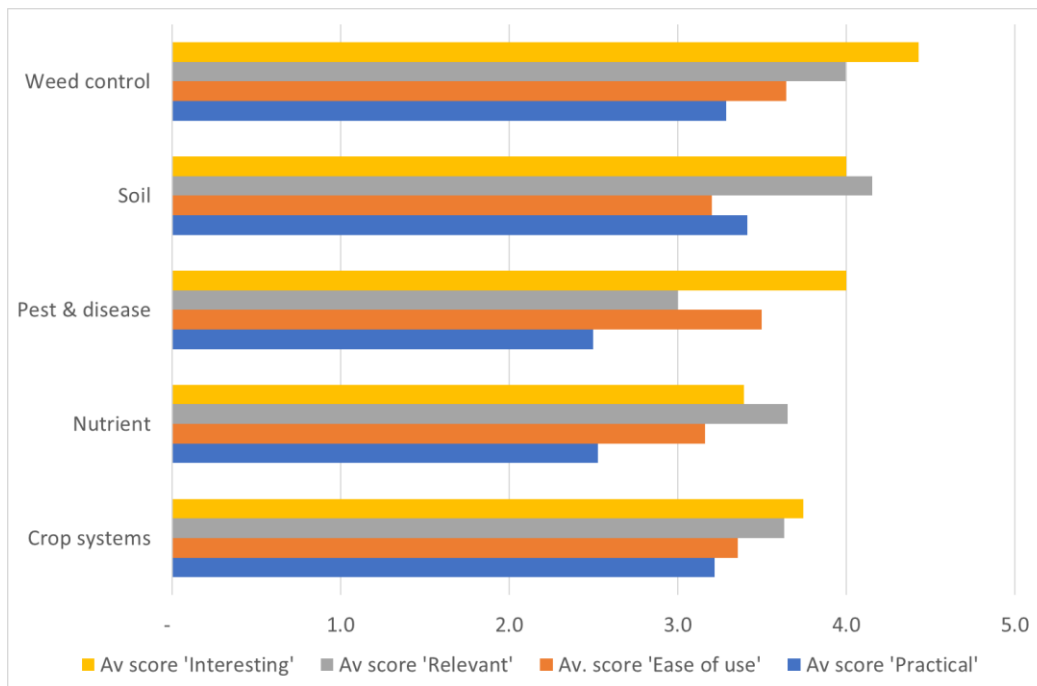
218 The category of **Cropping systems and crop specific** included tools that were both related to specific  
219 crops (e.g. cereals or lupins) and to the design of the cropping systems, such as rotation planners  
220 and websites with general information about organic agriculture. Most of the tools in this category  
221 were only evaluated by one or two groups.

222 The least popular category by far was that of **Pest and disease control**, where only one of the tools  
223 originally suggested was evaluated and one additional tool was suggested and evaluated by one  
224 group. The two tools that were evaluated (one atlas and one app) support the diagnosis of pest and  
225 disease and include recommendations for prevention as well as curative approaches. Farmers liked  
226 that tools showed the life cycles of pests with the support of good visual information. Tools that  
227 tackled specific pests or diseases were not relevant to all groups and some forecasting tools only  
228 have relevance in a specific region.



229

**Figure 1: Average rating of knowledge exchange tools by topic\***



230

231 \* Scores for interesting, relevant, ease of use and practical are based on 33 scored tools (using a five-  
 232 point scale (1 = low, 5 = high))

233 Source: Own data

234 **3.2 Preferences for different tool types**

235 All the KE tools were characterised as a tool type (format), with the tool offer being dominated by  
 236 Leaflets/Technical guides. The choice of tools evaluated in Table 2 and Figure 1 show a clear  
 237 preference for videos, whereas websites were least preferred.

238

**Table 2: Tools formats and preferences of the Farmer Innovation Groups**

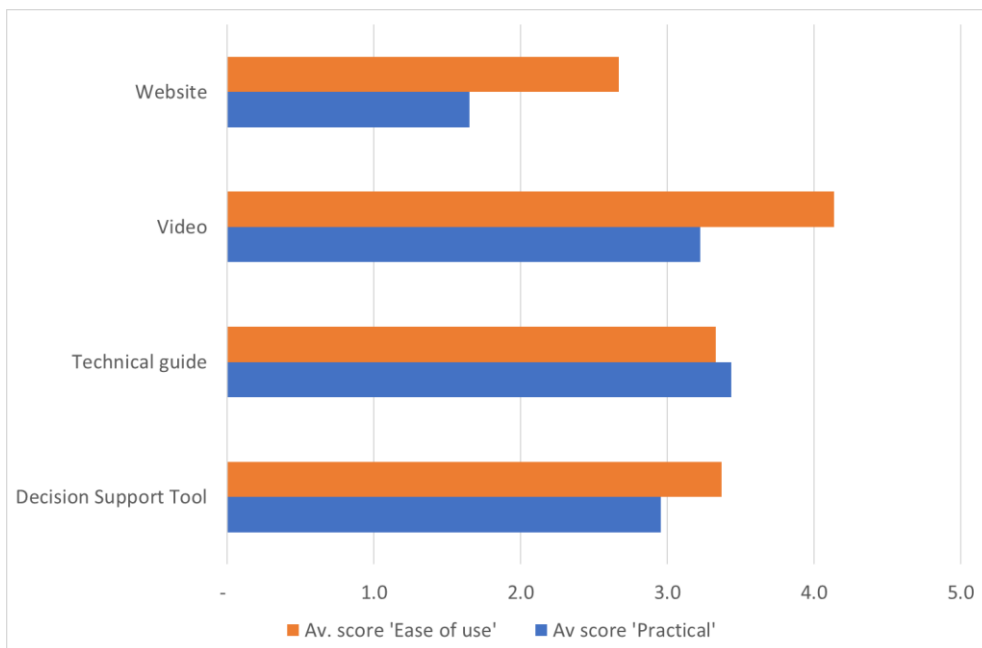
Tool type	Total No considered.	No. of tool evaluated
Website or web-tool	9	4
Video	4	4
Leaflets/technical guides	21	20
Decision-support/calculation tool	9	7
<b>Total</b>	<b>43</b>	<b>35</b>

239 Source: Own data

240 Tools were scored for 'ease of use' – which took into account the user friendliness of the type, the  
 241 instinctiveness of the layout and the energy it took to use them. This was considered particularly  
 242 important as farmers are busy. Figure 1 shows that on average, videos were considered the easiest to  
 243 use, followed by decision support tools. Interestingly websites were considered the least easy to

244 use. Participants also provided feedback on practicality, for which the technical guides score similar  
245 to videos and website received a low score.

246 **Figure 2: Average scores for ease of use and practicality of tools by type\***



247  
248 \* Scores for ease of use and practical are based on 33 scored tools using a five-point scale (1 = low, 5  
249 = high)

### 250 3.2.1 Feedback on videos

251 There was overall positive feedback on videos as a method of sharing knowledge, both from  
252 research and between farmers (see also 'Including visual information' below). The video type was  
253 well liked for ease of use and practicality, as a direct and simple way of learning from experience in  
254 the field – in particular the action of machinery: *"Videos are very direct and easy to understand"*  
255 (Group G); *"You can see the machines in action as if you were there yourself, ... you can see it at work*  
256 *from all sides..."* (Group C).

257 Feedback suggests that videos should be short (2-8 minutes). For example, the 20 minute long video  
258 on [Mechanical weed control in vegetables](#) was considered too long and it was suggested to *"cut the*  
259 *film in different parts so you can look into the machine you are interested in"* (Group C). However,  
260 other videos, e.g. the [Tilman.org videos](#), were criticised for being too general and simplistic, not  
261 covering the detail necessary for practical application. *"This is interesting as a kind of "first*  
262 *information". It's not detailed, but well done as an entry into this topic. If somebody wants detailed*  
263 *information a video is not the right thing"* (Group G).

264 A few groups suggested that videos could be directly linked to other tools, such as technical guides  
265 that provide further details for practical implementation (e.g. soil types, establishment methods,  
266 timings, seed rates, machinery settings etc). Others suggested that providing a series of short videos  
267 on the same topic might allow presentation of greater degree of detail.

### 268 3.2.2 Feedback on technical guides

269 Technical guides scored higher overall than videos for practicality, namely due to the level of detail  
270 they could go into. As an example, the technical guide [Earthworms: Architects of a fertile soil](#) was

271 evaluated by eight groups. The participants had quite different opinions: four groups found it  
272 interesting, easy to use and practical. They liked the presence of good pictures, clear subtitles and  
273 short texts and the overall format that can both be printed or read online. Other groups found the  
274 guide not so relevant, mainly because they found it to be too theoretical and overlapping with other  
275 tools they knew, or mainly aimed at beginners. Other sceptical comments included missing  
276 information about the effect of some machinery on the worms and the lack of a glossary explaining  
277 scientific terms.

278 It became clear that some groups preferred short technical guides of less than 20 pages that are  
279 clear and concise. One exception was a particular well-structured guide that made good use of visual  
280 information. The [Visual soil assessment: Field guide](#) is 84 pages long, but was considered to be useful  
281 because of the step-by step layout with photos, despite being seen as too long. On the other hand,  
282 the topic of the tool [Regionally adapted humus balance in organic farming](#) appeared interesting and  
283 relevant, but Group H, for example, found the tool not particularly practical to use because of the  
284 complexity and length and was uncertain about applicability to their conditions. The guide [Nutrient  
285 management in farms in conversion to organic](#) meanwhile received a mixed response, with one  
286 group finding it relevant and practical (Group D), whereas another (Group G) finding it complicated.

287 The colourful guide [Sort out your soil: A practical guide to green manures](#) was found to be interesting  
288 and practical, with sufficient detail about many green manure plants included. However, two groups  
289 (D and H) thought it was more for beginners than for experienced organic farmers and had some  
290 reservations about the transferability of the findings, whilst another group was doubtful whether or  
291 not growing green manure was feasible in their specific climate (Group I).

292 Longer guides, such as [Weed control in organic farming through mechanical solutions](#) (288 pages),  
293 were considered to be less easy to use because of long blocks of text with minimal use of visual  
294 information. However, one of Group H did report *“our experienced farmers read long materials, if  
295 they are well presented and relevant”*.

### 296 **3.2.3 Feedback on decision support and calculation tools**

297 The decision support and calculation tools (DST) evaluated included databases, software models and  
298 digital applications and whilst there was recognition of the potential, while some of those evaluated  
299 received very positive feedback, others did not come out so well. For example, the [Living mulch and  
300 cover crop tool box OSCAR](#) was rated highly by many groups. The user interface was considered to be  
301 easy to use, with simple check boxes supporting the toolbox to select cover crop species appropriate  
302 to one’s own farm conditions and objectives: *“The software is self-explanatory and therefore very  
303 easy to use”* (Group D). There was an appreciation of their *“playful”* nature - the ability to test out  
304 new ideas and bringing together scientific knowledge for practical solutions. *“The participants found  
305 the criteria approach relevant, the tool is easy to use and playful. Moreover, it is adaptable to the  
306 system of each farm”* (Group B). The toolbox also has an associated wiki page, which allows farmers  
307 to add their own experiences with different cover crops. This function was appreciated, although  
308 many were not sure they would have the time to contribute and others felt that users should be able  
309 to interact directly with the toolbox itself rather than a separate wiki.

310 There was, however, also some more critical feedback. The tool was considered to be lacking in  
311 detail – for example it covered only individual species, whereas some users were more interested in  
312 mixtures and the interaction of species in mixtures and crops following the cover crop in the  
313 rotation. Users also felt it needed to include information on the practical management implications;  
314 for example, identifying an appropriate ‘window’ for the cover crop in the rotation, including sowing

315 dates, seed rates etc. Some crops were also missing an indication of likely costs of the seeds and  
316 benefit in terms of yield and cost savings.

317 In contrast, other calculation tools were not considered to be easy to use in their current form and  
318 data entry in some cases was time consuming. For example, in relation to the N-flow simulation tool  
319 [NDICEA](#): *“Very good, needs a considerable time investment. Could be useful if you have the time”*  
320 (Group J). Some data such tools require are collected on farms and the farmers would like them to  
321 link to existing farm management software. Some were found to have complex user interfaces and  
322 limited data input options not fitting for specific situations and there was some concern about the  
323 reliability of output data.

324 Group J was supported by a researcher to apply the NDICEA nutrient dynamics model on their own  
325 rotations at a field scale to deepen their understanding of what was happening in the soil below  
326 their feet. With local data on climate, and soil and management practices for one field over a  
327 rotation, the model calculated nutrient surpluses and deficiencies over multiple seasons. Modelling  
328 the current rotations highlighted some common issues between the farms in relation to organic  
329 matter balances and suggested that nutrients were being lost through leaching, harvest and  
330 breaking the ley in the autumn. One farmer found the process of working through the scenarios  
331 together with the researcher really useful, particularly to step back and reflect was a *“real eye-  
332 opener”* that stimulated much discussion in the group and also in international knowledge exchange  
333 workshops.

334 Although the majority of DSTs tested were not considered particularly ready for practice because  
335 data-input was complicated, or output was either seen as too academic and not of practical  
336 relevance or seen as not reliable, there was an interest in the future potential in supporting users to  
337 pull together large amounts of complex information to make decisions tailored to their own farms.  
338 The use of DSTs as an indication of the relative risk and opportunity of different actions, as well as  
339 inspiring new ideas and approaches, was considered valuable.

#### 340 **3.2.4 Websites**

341 Examples of websites also received mixed feedback. The website [Knowledge platform for](#)  
342 [Agroecology](#) received most positive feedback. This resource is built around different agroecological  
343 principles and farmer testimonies for using them. Starting with farmer experience and practical  
344 examples seems to be a logical way to lead people into learning more in other, more detailed tools.  
345 The tool was liked by one group of farmers *“thanks to several videos of farmers telling their stories”*  
346 (Group F). Meanwhile, although appreciated for good overview of reduced tillage, the [Bioaktuell](#)  
347 website was considered to be more difficult to navigate and many were not able to find the more  
348 detailed technical guides contained on the site: *“Due to the different sections navigation is*  
349 *complicated.”* (Group D).

#### 350 **3.3 Emerging themes**

351 A number of common themes emerge from the feedback on the various tool types, which have been  
352 summarised in Table 3 and are described further in this section

353

**Table 3: Common themes in farmer feedback on KE tools**

😊 <b>Well liked</b>	😞 <b>Less well liked</b>
Visual information – pictures, tables, diagrams, videos of machinery in action	Long streams of unbroken text. Lack of images that farmers can relate to
Contextual information - tailored to different regions/farm types	Generalisation of a practice without a sense of 'place'. Unreliable data
Farmer experience - case studies, tips, dos and don'ts	Theoretical concepts with lack of application in the real world
Honest account of what works and, importantly, what doesn't work	'Promoting' an idea and giving a one-sided account. Omitting negative results
Easy to use and to find relevant information	Time consuming and difficult to navigate
Clear, plain language/glossary for technical terms	Overly complex, technical language
Makes relevant practical observations/recommendations	Lack of recommendations that take into consideration other elements of the farming system
Includes numbers – economics, yields, seed rates	No consideration of the impact on factors critical to farm decision making
User friendly way to interact with other farmers, researchers and advisors	Underutilised forums and difficult log in

355 Source: Own data

357 **3.3.1 The importance of farmer experience and practical implementation**

358

359 *'The best way to learn about something is to speak to someone who is doing it'* (Group J).

360 The importance of farmer experience and practical implementation is clearly reflected in the  
361 farmers' feedback on KE tools. One of the most common elements was that the Farmer Innovation  
362 Groups value KE tools that include or are based on experience of another farmer who has tried the  
363 practice. Tools that included case studies of farmers sharing their experiences with different  
364 practices, including details of the context, what worked and what didn't, and data on the impact on  
365 yields and economics, were appreciated. For example: *"The participants...appreciated the case  
366 studies (farmers' examples) and the technical detail represented on the figures...the farmers found it  
367 very practical"* (Group K) in reference to the technical guide on [Mechanical weeding in arable crops](#).

368 Farmers considered this specific information useful to help inform them whether a practice could be  
369 successful on their own farms. It adds a sense of 'place', in contrast to some technical guides, which  
370 generalised findings across many farm types and contexts. This was particularly true for the [YouTube  
371 channel](#) of a UK arable farmer. The farmer captures interesting insights and updates on his mobile  
372 phone as he walks his fields. Group J felt he is *"an ambassador for Organic Farming"* who is often  
373 innovating with new techniques – such as relay cropping and grazing wheat with sheep to control  
374 black-grass and shares his experiences. Watching such videos is *"Second best to standing in the field  
375 with him"*, according to members of the group. Farmers valued the honest analysis of the  
376 advantages and disadvantages *"...will be honest about what works and what doesn't work which is  
377 really important"* (Group J). The farmer also provides updates over time, so that viewers can follow  
378 progress on innovative practices he is trialling.

379 Groups discussed that it was important that tools should give recommendations and consider the  
380 practical implications at a farm level – for example, regarding seed rates, tillage practices, drilling  
381 dates, species selection etc. However, the groups did not always agree what 'practical' looks like.  
382 One group scored the [Müncheberg visual soil quality rating](#) positively and commented *"The test is  
383 easy to perform and does not require additional expensive equipment"* (Group L), whereas another  
384 group found the tool *"A bit difficult, maybe too theoretical, no practical suggestions"* (Group H).

385 The FiBL technical guide [Earthworms: Architects of fertile soils](#) shows a practical step-by-step process  
386 for counting earthworms as an indicator of soil biological activity. *"The guide has a very helpful "so  
387 what" summary at the end to help with management practices..... It would be useful to have more  
388 information about the effects of specific machines/equipment (rotary) on earthworm populations  
389 ....and how to mitigate some of the less beneficial practices, as what's bad for earthworms may be  
390 beneficial in another context."* (Group J). This illustrates that farmers are faced with the need to  
391 balance considerations for different parts of their farm when implementing recommendations and  
392 what works for one part of the farm may not do so for another. It appears that *'Sometimes [those  
393 writing the guide] forget that farms are businesses, we need to know if it is going to pay'* (Group J).

394 Farmers expressed an appreciation for an honest portrayal of the challenges and trade-offs  
395 experienced by those that have tried out the practices covered in the tools. Some KE tools were  
396 viewed as trying to 'promote' a certain practice and not cover potential set-backs and disadvantages.  
397 For example, in response to the US based video [Bringing the dirt to the doorstep](#) on reduced tillage,  
398 one Group B reported *"The farmers ...were sceptical about impartiality of the results: they suspected  
399 the authors to present only the successful results"* (Group B).

400 The group members found examples where a technique had failed under certain conditions to be as  
401 useful as where it had been successful. During practical testing, the Farmer Innovation Groups in  
402 Bulgaria and Italy both tested a roller crimper to destroy cover crops and create a mulch into which  
403 the following crop could be directly drilled. The trials in Italy showed relative success, but by contrast  
404 the trials partially failed in Bulgaria. The group attributed this to a late sowing date, soil compaction  
405 and lack of rain during the growing season but would like to carry out a further trial in future. In the  
406 discussion at the common workshops in France it was highlighted that it is essential to be clear  
407 about the different contexts in which the practice had been used to understand the difference.

408 Whilst many organic farmers in Europe are interested in reduced or no-tillage systems, they do want  
409 to see more trials under their own conditions to judge whether it could work for them. An exchange  
410 visit to Austria invited members of some of the Farmer Innovation Groups to meet US researchers to  
411 talk about their experience. The direct exchange allowed the opportunity for two-way learning, as  
412 the advisors and researchers engaged in the process also gained new knowledge and insights.  
413 Bringing together farmers and scientists and organising national and international exchange visits,  
414 farm walks and on-farm trials all play an important role in the innovation process.

### 415 **3.3.2 Including visual information**

416 Another common theme in the discussion of several different tools was the appreciation of photos  
417 and visual information, which was expressed in the preferences for videos but also in response to  
418 technical guides. The tool [Mechanical weeding in arable crops](#) received positive feedback for  
419 combining short sections of text with photographs showing the mode of action of a finger weeder  
420 and weed control interventions in the rotation. *“Although it is quite a lot of information the layout  
421 makes it easy digestible. You can read it as separate leaflets. There are lots of practical case studies,  
422 pictures and practical tables.”* (Group C). Guides that contain photos, diagrams and tables are seen as  
423 more useful than long streams of text.

424 Photographs were also used to convey essential information on crop health, crop establishment and  
425 soil condition. For example, the [CroProtect App](#) was rated positively for its visual content: *“Photos  
426 [in the App] are helpful visual cues for identification of pests in the field”* (Group J). Additionally, visual  
427 information can help to overcome language barriers: *“even without translation or with only some  
428 small keywords, you can learn a lot from a video”* (Group C).

### 429 **3.3.3 The importance of detail about context and ‘place’**

430 The OK-Net Arable project aimed to share tools between countries and many groups tested tools not  
431 particularly developed for their specific soil, climate and socio-economic conditions. Several of the  
432 farmer groups fed back that many of the tools were too general or not appropriate to their specific  
433 conditions.

434 The video [Bringing the dirt to the doorstep](#) on the challenge of weed control with reduced tillage is  
435 based on case studies in the US that the farmers did not consider to be relevant to the European  
436 farming systems. Participants in Farmer Innovation Group B found it difficult *“to transpose the  
437 results to French pedoclimatic conditions because (i) there was a lack of context information in the  
438 video and (ii) the experimentation is set in the US”*.

439 Similarly, in response to the [Living mulch and cover crop tool box OSCAR](#), one group commented:  
440 *“Highly relevant for the soil fertility issues raised by the farmers. However, it seems too generic and  
441 does not offer specific solutions (cover crops) for the Marche region”* (Group F). The same group  
442 commented on the rotation calculation tool ([ROTOR](#)) that it does not cover important details: *“...the  
443 tool does not take economic aspects of the cropping system into account and it seems specifically*

444 *suitable for the Baltic area, so rather far from the agro-ecological characteristics of the Marche region.*  
445 *This makes its practical value very low” (Group F). Commenting on the technical guide [Mechanical](#)*  
446 *[weeding in arable crops](#), another group highlighted the need to adapt to local conditions: “In all*  
447 *details it needs to be adapted into the Hungarian agro-ecological and farming conditions” (Group I).*

448 Details such as soil type, rainfall, establishment method, position in the rotation are all critical to  
449 help farmers make the decision of whether a practice is suitable for their farm or how they may  
450 adapt it. As every farm is different, it is unlikely that farmers will adopt a practice exactly as it is  
451 presented in a tool, but providing more details helps them to interpret how the practice could fit  
452 into their own situation. For applied knowledge, such as practices for weed control, cover crops and  
453 reduced tillage, information about the local context was found to be critical, whereas the groups  
454 found knowledge that covers more ‘fundamental’ topics, such as soil biology and soil monitoring  
455 techniques might be transferable, irrespective of the local context.

## 456 **4 DISCUSSION**

457 In the project, groups of organic farmers in several EU countries used KE tools that were presented  
458 on a common platform. The evaluation of tools in the OK-Net Arable project by farmer groups was  
459 an attempt to move beyond the linear model of innovation, where practices are developed by  
460 scientists, disseminated through intermediaries and then used by farmers, towards an integrated  
461 model of KE and contributing to the question how this knowledge exchange can be carried out  
462 across borders and by using the internet.

463 One important question when talking about taking KE online is the question whether, for what and  
464 how frequently organic farmers use the internet. In a survey of organic farmers as part of the OK-Net  
465 Arable project, Ortolani and Micheloni (2016) found that only about 30% of farmers in their survey  
466 considered the internet to be an important source of information, with time being the most  
467 significant barrier. The proportion is higher among younger farmers and the increasing use of  
468 smartphones will extend the time periods during which farmers can access the Internet to look up  
469 technical information. This stands in contrast to a study in the South West of England which found  
470 that 89% of farmers use the internet in the context of the farm business management for sending e-  
471 mails, reading farming news online and to apply for government grants (Buttler and Lobley, 2012),  
472 although only a 9% used internet discussion boards and 6% used internet blogs. Since the sector of  
473 KE is developing very fast, there is a need to repeat surveys to get up-to-date insights into  
474 farmers and advisors use of the internet and digital tools.

475 In the same English survey, farmers were also asked to name the three sources they trusted most in  
476 terms of the knowledge imparted. They cited advisors and other farming professionals (52%), the  
477 farming press (36%), business professionals (31%) and farming friends (29%) (Buttler and Lobley,  
478 2012). This stands in slight contrast to the preferences of the organic farmer groups in the OK-Net  
479 Arable project, who appear to trust other farmers more than farming professionals. This may be a  
480 reflection of the shortage of farming professionals that are well trained and qualified in organic  
481 farming in several of the countries in which the groups operate. Trust in groups that learn together  
482 develops through mutual support, so that both positive and negative experiences from trial and  
483 error can be explored and learning emerge from a shared interest in a problem or challenge  
484 (Moschitz et al., 2014). There is, however, also evidence that agronomist-farmer encounters that are  
485 underpinned by trust, credibility, empathy, and consultation could provide an effective context for  
486 knowledge exchange—potentially facilitating farmers’ transformation to more sustainable



487 management practices (Ingram, 2008). There is a need to consider what factors farmers value in KE  
488 tools and face-to-face KE and how and if these factors can be included when taking KE tools online.

#### 489 **4.1 What tool formats are preferred?**

490 Each tool type (leaflet/technical guide, video, website and DST) has relative advantages and  
491 disadvantages and provides a slightly different function. Some are also better suited to certain types  
492 of information. For example, videos can work better for introductory information and inspiration,  
493 whereas technical guides provide detail for practical implementation. Moreover, different users are  
494 likely to prefer certain formats over others and therefore providing a range of options is important  
495 to be able to reach as wide an audience as possible.

496 The generation of web-hubs, like the [knowledge exchange hub for agroecology](#), create the  
497 opportunity for combining different formats in a single location, for example by linking to farmer  
498 profiles and videos. This is an idea that has been considered in the design of the knowledge platform  
499 of the OK-Net Arable project (<http://farmknowledge.org>), where videos are used as, and connected  
500 to, other tools. In this way, videos can be an easy-to-use 'hook' and inspiration for farmers to then  
501 delve deeper into existing information to learn how to apply certain practices on their own farms.

502 Our results also show some recognition of the potential of digital Decision Support Tools (DSTs),  
503 which synthesise information in a way to support farmers in making decisions – those assessed  
504 included databases, software models and digital applications. According to Rose et al. (2016), such  
505 tools are designed to help users make more effective decisions, by leading them through clear  
506 decision stages and presenting the likelihood of various outcomes resulting from different options.  
507 However, whilst decision-support tools may have potential to tailor management practices to the  
508 specific context of each farm, in their current form they frequently lack this detailed information  
509 about location and experience-based knowledge to support decisions (Rose et al., 2018). Our  
510 findings therefore suggested some scepticism that in their current form, DSTs could replace the  
511 ability to consider different types of contextual knowledge, such as the tacit knowledge of each  
512 farmer, the historical rotations, weather and soil types. They suggest a role in supporting farmers,  
513 rather than trying to replace the farmer or advisor in making decisions. *"Farmers and agronomists  
514 require decision support not decision making because they are the ones that decide what is most  
515 appropriate for their local conditions"* (Bruce, 2016 p90).

516 Finally, DSTs and online tools that force farmers to be more office-based in their decision-making  
517 ignore the spatialities of decision making and the workflow on farm (Rose et al., 2018). Another  
518 consideration for future tool development is to consider the value in user centred design (UCD). For  
519 example, Rose et al., (2018) suggest that engaging users in the co-development of Decision Support  
520 Systems, including taking a decision support assessment prior to building and launching a product,  
521 may enhance usefulness and uptake.

522 It is likely that e-learning could also be a useful online KE tool, but the farmer groups did not  
523 evaluate any e-learning tools systematically. The OK-net Arable project developed a facilitated E-  
524 learning course that introduces some of the KE tools on the knowledge platform in five different  
525 thematic modules. The course was taken by 70 participants from 23 countries and evaluated largely  
526 positively and is now offered as self-learning course [Challenges of Organic Arable Farming](#) on the  
527 knowledge platform (see Mohamad et al., 2018). This experience suggests that e-learning should be  
528 explored further. However, further research would be needed to get better understand why farmers  
529 prefer certain tools and interactions and how this can be used to improve KE in organic farming.

## 530 4.2 Keeping it practical

531 Weed control, soil fertility and nutrient management were the two most important thematic topics  
532 that groups chose for tool feedback and practical trials, which corresponds well to the most common  
533 challenges reported by the groups earlier in the project (Cullen et al., 2016). Our results show that  
534 the farmers value practical experiences in KE tools, related to the agronomic conditions (soil,  
535 climate, seed rates) and costs and benefits that help to inform their decisions whether or not a  
536 practice is useful for their own farm. The farmer decision-making process is strongly influenced by  
537 practical, but also by legal means and financial factors (Blackstock et al., 2010). They appreciate  
538 succinct tools that clearly outline practical implications and recommendations, but this does not  
539 mean that they are looking for information that has been generalised to apply to all conditions.  
540 Understanding how certain practices have been applied in different contexts (soil, climate  
541 conditions, farming systems), the specific field operations that were performed (machinery,  
542 cultivations, position in the rotation etc.), the impact on yields and farm economics are all details  
543 that the farmers found valuable but lacking in many of the tools. Also, often missing were honest  
544 accounts of negative impacts – what didn't work and why – which was also considered to be very  
545 useful. Many of those elements that farmers felt were missing in existing KE tools are exactly those  
546 they valued in direct communication with other farmers, advisors and researchers. This may be one  
547 of the reasons why farmers express a strong preference for farmer-to-farmers KE rather than KE  
548 tools written by researchers. According to a study with small-scale farmers in four European  
549 countries, apart from independence the combination of tacit and codified knowledge is important  
550 for credibility of source (Sutherland et al., 2017).

## 551 4.3 Providing a context and farmer experiences

552 Overall, many of the tools were considered to present practices without a sense of place or  
553 reference to the contexts in which it could work or not. Farmers pull together information from  
554 many sources to gain knowledge of their own systems. This is often hindered by lack of research  
555 relevant to their own context – e.g. soil type, farming system, agroclimatic conditions (Röling, 1990).

556 Scientific knowledge is always embedded in specific contexts, but many tools seek to be broadly  
557 compatible across farms/regions/countries. As such, information tools developed by scientists for  
558 farmers are often considered to provide a placeless '*view from nowhere*' (Rose et al., 2016 p14). Our  
559 findings confirm the conclusion of Rose et al. (2018) that farmers value knowledge that is  
560 contextualised. They value experience in the field and the opinions of advisors and other farmers  
561 that know the farm and put less trust in scientific recommendations where the context is not  
562 clear/realistic (Rose et al., 2018).

563 This value of location-based knowledge may thus be one of the critical success factors of direct  
564 farmer-farmer KE and careful consideration is needed as to how this can be provided online. This is  
565 an area to improve in future tools, perhaps adapting tools to be relevant to different regions or farm  
566 types. Despite the need to synthesise results and keep tools relatively succinct, researchers creating  
567 KE tools should be mindful of the tendency to over-generalise information. Providing case studies  
568 and background to the trial sites is an important detail that farmers appreciate. However, this also  
569 depends on such research outcomes being available for organic agriculture - highlighting a significant  
570 research gap.

571 Overall, feedback from farmers reinforced that they are unlikely to adopt a practice directly as  
572 scripted in a tool. Instead, they tend to refer to information tools once they have already explored

573 ideas by talking to others, and then ‘interpret’ how that information may be relevant to their own  
574 situation. “*For farmers and advisors using tools, decisions will be a hybrid of different forms of knowledge*”  
575 (Rose et al., 2018 p15).

#### 576 **4.4 Providing visual information through videos and images**

577 In our results, the farmers expressed a clear preference for visual information. This may be related  
578 to the fact that humans are neurologically wired with an overwhelmingly visual sensory ability  
579 (Brown, 2014 p222) and that pictures are not only more effortless to recognise and process than  
580 words, but also easier to recall (Dewan, 2015). It is likely that farmers are used to using visual cues in  
581 the field every day to make decisions about the condition of their soil, crops and livestock and so  
582 also relate well to seeing practices in action in other places. Visual information could be used more  
583 widely in other online tools. Careful selection of practical images and other visual information  
584 (flowcharts, diagrams, infographics) in written guides, websites and Decision Support and  
585 Calculation Tools could improve their practicality.

586 The medium of the video in particular opens up a huge opportunity to take experience online and is,  
587 as one farmer put it “*second best to standing in the field*”. There is also potential for sharing updates on  
588 demonstrations and trials – both on farm and at research stations for example in the form of video  
589 diaries or vlogs. Direct dialogue can permit feedback to the research community on what is  
590 appropriate and realistic and thus increase research impact (Bruce, 2016) and give rise to new  
591 insights and solutions. This could be an opportunity to engage other practitioners in an online co-  
592 innovation process, in which they are able to interact, ask questions and make suggestions to those  
593 running the trials. However, the experience from the knowledge platform of OK-Net Arable has  
594 shown that it is challenging to engage users in online interaction and trials would need to have  
595 sufficient staff time resources to engage with such online interactions. With improving smartphone  
596 technology, it is increasingly possible for farmers, advisors and researchers to make their own videos  
597 and share these online through platforms such as YouTube, opening up a new space for dialogue.  
598 Some farmers may do this for altruistic purposes, but most will need to see clear benefit to investing  
599 time in sharing their experiences (Bruce, 2016).

600 Videos can be used to film in-field KE activities – such as farm walks – sharing those discussions with  
601 a wider audience. Social media can also be used to bring questions and answers to on-farm events  
602 from remote participants.

#### 603 **4.5 Seeking opportunities for dialogue and co-innovation.**

604 Bringing farmers, advisors and researchers together in the Farmer Innovation Groups of OK-Net  
605 Arable and through international exchange visits and workshops led to the production of new ideas  
606 and insights that perhaps would not have emerged otherwise. Farmers were motivated to test the  
607 tools in practice and share their findings with others on the farmknowledge.org knowledge platform,  
608 in videos and as practice abstracts. Members of different groups were able to interact in meetings  
609 and discuss openly what worked and what didn’t and how that related to the context – soil type,  
610 slope, rainfall etc. sharing ideas and experiences.

611 In this sense, the Farmer Innovation Groups can be seen as ‘boundary organisations’, i.e.  
612 organisations that work on the boundary between science and farming exemplify this convergence  
613 of knowledge and roles (Carr and Wilkinson, 2007). They provide a new space for farmers, advisors  
614 and scientists to interact. This in turn enables movement away from a linear process of knowledge  
615 transfer from science to practice towards a co-innovation process, enabling researchers to learn

616 from farmer experience, deepen their understanding of what is realistic on farm and all actors to  
617 learn from each other. This experience therefore reflects previous findings that such processes  
618 constitute a powerful force for stimulating innovation and co-production of new knowledge (Carr  
619 and Wilkinson, 2007; Almekinders, 2011).

620 However, despite the momentum generated by Farmer Innovation Groups meeting on exchange  
621 visits, there was reluctance to continue these discussions online. This confirms findings of Buttler  
622 and Lobley (2012), who also found farmers reluctant to visit internet discussion forums. Similarly,  
623 the opportunity to interact with the discussion forum on farmknowledge.org was not taken up, and  
624 the language barrier and the lack of a critical mass of active users were mentioned as reasons (see  
625 Gócs et al., 2018). An alternative to seeking to establish forums or integrate other interactive  
626 functions into online tools could be to tap into existing social media networks. Utilising these forms  
627 of online communications also offers the opportunity to bridge the gap between actors separated  
628 spatially (e.g. in different organisations) and/or by perspective (Klerkx and Proctor, 2013). Building  
629 on established relationships and user profiles may create a more interpersonal experience and tap  
630 into a critical mass of people using these channels. Finding new ways to integrate discussions on  
631 these channels with platforms such as farmknowledge.org remains a challenge for the future.  
632 Experience with the [www.agricology.co.uk](http://www.agricology.co.uk) website hub in the UK, which integrates social media  
633 channels (Twitter, Facebook, YouTube and Instagram), suggests that using the handle @agricology  
634 can sometimes encourage users to ask each other questions or engage in polls and discussions.  
635 #AgrichatUK is another peer to peer twitter home for weekly discussions on specific farming topics.  
636 Similarly, social media channels that enable discussions in smaller focus groups have also shown  
637 promise. A group of farmers from the UK and France that met on an OK-Net Arable exchange visit on  
638 intercropping chose to set up a *WhatsApp* group to enable ongoing discussions and informal chats,  
639 the sharing of photos, updates and anecdotes from their own trials.

## 640 5 CONCLUSIONS

641 Online Knowledge Exchange (KE) tools can play a valuable role in bringing together knowledge and  
642 experience on good practice in organic arable farming in Europe and contribute to improving yields.  
643 Topics chosen most frequently for evaluation in workshops and in practice include soil quality and  
644 fertility, nutrient management and weed control corresponding with the topics identified as key  
645 challenges by the group earlier in the project. For weed control tools integrating preventative with  
646 direct methods were discussed favourable. Only a few crop specific tools and tools related to pest  
647 and diseases management were evaluated, which maybe a reflection of the tools presented rather  
648 than the importance of the topic.

649 Critical considerations for those developing online KE tools are to:

- 650 • Include farmers' experience about a specific practice, for example through case studies and  
651 farmer profiles
- 652 • Provide clues about the context: when did it work/not work
- 653 • Include visual information – photos, graphics and videos
- 654 • Support co-innovation through farmers interacting with the research results/researchers  
655

656 There is no silver bullet in relation to tool formats and a range of tools are necessary to support  
657 farmers to take new knowledge into action. Videos have potential for capturing field experiences,  
658 such as trials and demonstrations, but technical guides may allow more detail and fundamental  
659 knowledge to be conveyed.

660 Sharing case studies, tips, successes and failures in online KE tools can support farmers to judge for  
661 themselves how a practice may work on their own farm and make use of the fact that farmers trust  
662 the experience of another farmer. Furthermore, providing more details of the context in which a  
663 practice has worked or not worked in an honest way, including the climate, rotation and other on  
664 farm management practices, is also valuable. The final decision whether or not to try or use a new  
665 practice lies with the farmer. Decision Support Tools should be co-developed these in collaboration  
666 with farmers and could help in tailoring scientific information to individual farm contexts. Adopting a  
667 a user centred design approach for future tool development is likely to enhance usefulness and  
668 uptake. Tool developers should also consider including information on negative impacts and  
669 situations in which practices failed. Details on the implications for management, economics and  
670 yields would also be valuable. Integrating more relevant visual information such as photos and  
671 diagrams in tools could additionally improve the ease of use and practicality for the farming  
672 community. Online KE opens a whole new space for co-innovation between farmers, researchers  
673 and advisors. Further studies could seek to analyse the processes involved in digital co-innovation  
674 approaches, including the how social media can be utilised in contributing to knowledge exchange  
675 between farmers and farmers and researcher. However, despite the considerable potential, online  
676 KE tools should not be expected to replace face to face in-field KE. The farmers engaged in the  
677 project hugely valued the opportunities for international face-to-face exchanges that were created  
678 during the project and were inspired to reflect on their own practices. This in turn has the potential  
679 to improve organic arable yields. Online KE tools, supported by social media channels to enable  
680 discussion and allow feedback and informative chats, can complement this face to face in-field KE  
681 and together they could play an increasing role in improving best practice in organic farming in  
682 Europe and beyond.

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