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Smallholder farmers' information behavior differs for organic versus conventional pest management strategies: A qualitative study in Uganda

Nikola Diemer [a, 1], Philipp Staudacher [a, b, *, 1], Aggrey Atuhaire [c], Samuel Fuhrimann [d], Jennifer Inauen [e]

[a] Eawag, Swiss Federal Institute of Aquatic Science and Technology, Überlandstrasse 133, 8600, Dübendorf, Switzerland
[b] Institute of Biogeochemistry and Pollutant Dynamics, CHN, Universitätstrasse 16, ETH Zürich, 8092, Zürich, Switzerland
[c] Uganda National Association of Community and Occupational Health (UNACOH), Plot 37/41 Buganda Road, YMCA Building, Wandegeya Mail Stop, 12590, Kampala, Uganda
[d] Institute for Risk Assessment Sciences, Utrecht University, 3584, CM Utrecht, the Netherlands
[e] Institute of Psychology, University of Bern, Fabrikstrasse 8, 3012, Bern, Switzerland

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ABSTRACT

Conventional pesticides are associated with numerous human and environmental health risks. Nevertheless, an increasing number of smallholder farmers in low- and middle-income countries are using conventional pesticides. Adopting safer pest management requires farmers to obtain new information. However, little is known how farmers develop an information need, seek, and use pest management related information, and whether this process differs for organic and conventional pest management strategies. In this qualitative study, we investigated pest-related information behavior in depth, from farmers' own perspective. Using an ethnographic approach, we conducted 46 semi-structured interviews, 15 on-farm observations and 302 structured questionnaire interviews with farmers in Wakiso District, Uganda, in 2017. Our results indicated that farmers develop information needs when adopting new farming practices, or when presented with disruptive information (e.g. when new pests emerged). This prompted farmers to seek information actively, or they received passive information. Whether farmers used the new information depended on successful trial of the new pest management strategy, and on the credibility of the source. Most revealing, our results suggested important differences in information behavior between conventional and organic pest management strategies. Sources of information for conventional pesticides were well-integrated into farmers' daily lives and comprised pesticide dealers and fellow farmers. Conversely, information on organic strategies was provided through external sources (e.g. NGOs), and was not available at times when farmers developed an information need. Our results imply that farmers are most likely receptive to organic pest management information at times when they develop an information need (e.g. when encountering a new pest). To promote safer pest management, information about organic and integrated pest management should be made continuously available in farmers' lives. Furthermore, we recommend leveraging established information channels (e.g. dealers) among pesticide users to promote safer use practices.

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1. Introduction

Smallholder farming, is an important source of global food production and a major source of income in many low- and middle-income countries (LMICs) (Boserup, 2017). The majority of smallholder farmers apply conventional (i.e. synthetic) pesticides as their first and often only pest management tool (Hayes and Hansen, 2017). Low educational level, insufficient training, lack of knowledge and

* Corresponding author. Eawag, Swiss Federal Institute of Aquatic Science and Technology, Überlandstrasse 133, 8600, Dübendorf, Switzerland
E-mail addresses: nikola.diemer@posteo.de (N. Diemer), philipp.staudacher@eawag.ch (P. Staudacher), atuagrey3@gmail.com (A. Atuhaire), s.fuhrimann@uu.nl (S. Fuhrimann), jennifer.inauen@psy.unibe.ch (J. Inauen).
[1] Joint first authorship.

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pursuit of high profits were reported to be indicators for higher than recommended pesticide use (Abadi, 2018; Akter et al., 2018). However, conventional pesticides are associated with numerous human and environmental health risks (Hayes and Hansen, 2017).

To avoid these adverse effects, a reduction of pesticide use, specifically switching to organic or integrated pest management (IPM) strategies, is advocated (Mie et al., 2017). Organic strategies include mechanical weeding, picking off insects from infested plants, or using natural pesticides (Lampkin et al., 2000). IPM includes cultural and ecological host plant resistance, mechanical, behavioral and biological methods, and the careful use of conventional pesticides (Pimentel and Peshin, 2014). Despite their advantages, organic and IPM strategies have not been widely adopted (Parsa et al., 2014). To make the switch from conventional to organic or IPM strategies, farmers must first make a paradigm shift (Jouzi et al., 2017). While behavior change is complex, many theories propose that obtaining information is the first step to change (Ajzen, 1991; Weinstein and Sandman, 1992). However, little is known about how smallholder farmers obtain pest management information.

1.1. A model of information behavior in agricultural systems

Two promising approaches to understanding farmers' information behavior are the sense making theory (Dervin, 1998), as applied in Munyua and Stilwell (2012), and the information behavior model created by Wilson (1999). An integrated, simplified theory of farmers' information behavior based on the two above-mentioned approaches is depicted in Fig. 1. It is framed by the *initial situation*, which leads to an *information need*. The need for information can consequently lead to *information seeking* and, subsequently, to the decision to use (or not use) the encountered information. The *future farming practice* is the outcome of the information behavior. A farmer's decision to use the encountered information may be reflected in an adapted farming practice. On the other hand, if a farmer rejects the information, this may lead to further *information needs* and *information seeking* or simply the continuation of the current farming practice.

1.2. Information behavior in smallholder farming

In sub-Saharan Africa, research has reported a large degree of variety in farmers' *information needs*, which mainly depend on individual activities, with pest and disease management always being extremely important (Byamugisha et al., 2008; Tandi Lwoga et al., 2011). Recent, Ugandan studies have reported a lack of general knowledge on pest management strategies aside from pesticide use (Okonya and Kroschel, 2016), scant knowledge about the uses and risks of conventional pesticides (Oesterlund et al., 2014), and a relationship between low knowledge scores regarding pesticide hazards and the effectiveness of public health interventions, such as awareness campaigns (Muleme et al., 2017).

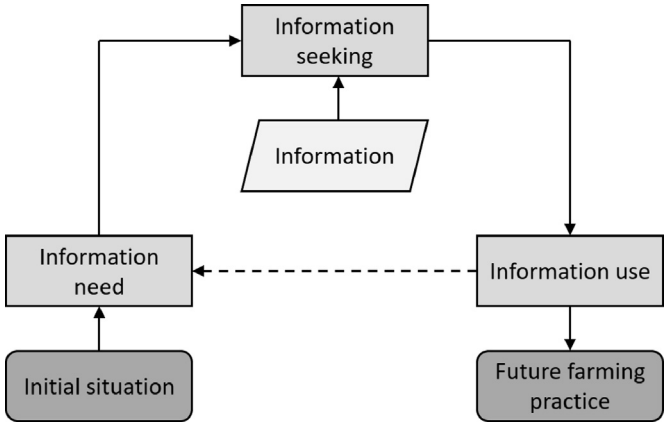

Fig. 1. Schematic of farmers' information behavior following Wilsons' model of information behavior (Dervin, 1998; Wilson, 1999).

Further research has been concerned with *information seeking*, specifically the use of *information sources* in this process. In Turkey, Boz and Ozcatalbas (2010) differentiated between traditional (e.g., personal experience, family members, and neighbors) and modern *information sources* (e.g., government extension services, mass media, pesticide dealers). Pesticide dealers seemed to be the most frequently used *information source* of pest management information. Similarly, studies in Kenya found two parallel information systems, a local, indigenous one that included neighbors, other farmers, and family members, as well as an external, science-based, globally applied information system. While most farmers used both, only half of them were able to relate one to the other (Munyua and Stilwell, 2013).

Overall, smallholder farmers seem to prefer mouth-to-mouth information (Byamugisha, 2009; Elly and Epafra Silayo, 2013), e.g., that was obtained via interactions with neighbors, families, and community-based organizations (Rees et al., 2000). These *information sources* can also provide opportunities for observational learning (Foster and Rosenzweig, 1995).

Some farmers receive information from external sources, e.g., extension services, which can provide farmers with knowledge and new findings on agricultural topics. Munyua and Stilwell (2013) found this to be the most important *information source* for farmers in Kenya. However, research also shows that many farmers lack an awareness of extension services (Boz, 2002; Tandi Lwoga et al., 2011). They further cite their high cost in terms of time and money (Boahene et al., 1999), their poor response to *information needs* (Tandi Lwoga et al., 2011), and their lack of coverage (Muyanga and Jayne, 2006).

After acquiring information, a farmer decides whether and how to use this information. Ugandan farmers reported that the quality of the information, which is sometimes inaccurate or insufficient, can hinder their use of such information, as can a lack of resources (Byamugisha, 2009). Additionally, incomplete knowledge can be a major hindrance to the adoption of new farming ideas (Foster and Rosenzweig, 1995), while better knowledge can reduce pesticide use (Feder et al., 2004).

Few studies have investigated whether farmers' information behavior is related to specific pest management strategies. One study indicated the importance of access to information regarding the adoption of organic or IPM strategies (Tatlıdil et al., 2009).

In summary, previous research has provided important insights into certain aspects of farmers' information behavior (e.g., the *information sources* used). However, a comprehensive understanding of farmers' information behavior regarding pest management from farmers' perspectives, and how this may differ between conventional and organic farmers remains lacking. In the present study, we aim to extend previous research on farmers' information behavior with smallholder farmers in Uganda by i) providing an in-depth view on farmers' subjective experiences related to pest management information behavior and ii) differentiate between farmers' information behaviors regarding conventional and organic pest management strategies.

2. Methodology

An ethnographic approach was chosen, focusing on farmers' subjective experiences of pest management. Ethnography is a form of observation where the researcher collects qualitative data from various sources, focusing on the cultural meaning of actions of the

individuals involved (Griffin and Bengry-Howell, 2017). This approach is therefore appropriate to study subjective experiences as researchers do not superimpose their views, but rather elicit unforeseen perspectives. Using a grounded theory approach, we analyzed the data with the goal of gaining in-depth insights in farmers' information behavior, and extending theory (see Fig. 1) rather than testing it. (Glaser and Strauss, 1980). Grounded theory is a systematic, iterative approach of inductive reasoning, whereby a theory forms from the data (rather than being superimposed (Charmaz and Henwood, 2017). Additionally, quantitative data from a cross-sectional survey are used to corroborate some of the qualitative findings.

2.1. Setting and study area

This study was conducted in Central Uganda in the peri-urban district of Wakiso, in the three farming Sub-Counties of Mende, Masulita, and Gombe, from October to November 2017. Wakiso is the most densely populated district in Uganda, with two million inhabitants (UBOS, 2014). The main subsistence crops in the area are bananas, beans, cassava, groundnuts, maize and sweet potato. Additionally farmers grow cash crops such as coffee and tomato (UBOS, 2017). The wet tropical climate encourages rapid plant growth but also favors disease outbreaks. There is a wide network of private importers, distributors, and retailers of conventional pesticides across the country. This makes pesticides affordable and readily available to farmers within their community settings. This study was part of the Pesticide Use in Tropical Settings (Pestrop) Project, which aims to deepen understanding of the environmental, health (Fuhrimann et al., 2020; Palzes et al., 2019), and regulatory dimensions of pesticide use in conventional and organic agriculture in LMICs (Fuhrimann et al., 2019).

2.2. Data collection

All study materials and procedures were approved by the higher degrees, research, and ethics committee of the School of Public Health at Makerere University, Uganda (Protocol 522), and the Ethical Board of the Ethikkommission Nordwest-und Zentralschweiz in Switzerland (EKNZ-UBE, 2016–00771). Written informed consent was obtained from all participants prior to participating in this study.

Ethnographic data were gathered through household visits (documented in the form of written observation protocols and field notes), and face-to-face interviews (using a semi-structured interview guide and an audio recording device). The 50 interviewed smallholder farmers were a sub-sample of a random sample of farmers of the Pestrop study. The criterion for inclusion was having taken a decision-making position regarding pest management on their farms (see Table 1, note that age ranges are provided to ensure the anonymity of participants). Subsequently, interviews where translated into English and transcribed using a consistent transcription scheme.

To further corroborate some of the qualitative findings, quantitative data from the Pestrop study ($N = 302$ randomly selected farmers) were analyzed to provide a quantification of the sources of information revealed in the present study (comprehensive results of this survey will be published elsewhere).

2.3. Data analysis

The first author, using two methodological approaches, analyzed the data, and the research team verified the coding through discussion. First, a qualitative content analysis (Mayring, 2014) of all the interview transcripts and observation protocols was performed to identify the pest management practices of the participating farmers. The entity of analysis was the pest management strategy (conventional vs. organic), and not the individual farmers, because most farmers used both pest management strategies.

Second, the interview transcripts were submitted to a deeper analysis using the grounded theory method, which includes three steps: open coding, axial coding, and selective coding. The analysis was performed using MAXQDA (VERBI Software, 2017).

In the first step of the grounded theory approach (open analysis), the first author created an extensive list of codes that were subsumed in various categories and thereafter further particularized by analyzing their specific properties and dimensions. In the second step (axial coding), these categories were put into context (Strauss and Corbin, 1994), increasing understanding and developing a systemic perspective. Following the coding paradigm of (Strauss and Corbin, 1998) we then focused on three factors: *Conditions* under which a certain social phenomenon occurs, *actions and interactions* that take place with reference to the phenomenon of interest, and *consequences* that result from these actions. Thereby, relations between categories were discovered and developed. With this context in mind, we outlined and integrated the categories into the central categories of *information need, information seeking* and *information use,* according to the farmers' information behavior approach (Fig. 1). In this process of selective coding the theoretical approach was refined by use of the theoretical memos developed during coding, figures visualizing relationships between concepts, and field notes produced throughout the process of analysis.

The results are presented next, providing direct quotations supporting or contradicting the coding solution as a means to verify their validity. Note that interpretations are separated from the results, but are presented in the same section as they form the core part of the findings in this kind of research.

3. Results and interpretation of findings

3.1. Sample description

In the qualitative sample ($N = 50$), the majority (68%) of participants reported using both organic and conventional pest management strategies, while 12 and 4 only used conventional and organic strategies, respectively (Table 1). The organic strategies reportedly used by farmers were physical strategies (66%), homemade pesticides (36%), and repellents (4%).

The quantitative sample ($N = 296$) consisted of 59% male and 41% female participants. The mean age was 48 years. In this survey, 52% self-identified as conventional farmers, 30% perceived themselves as organic farmers, and 19% conducted both practices in parallel.

3.2. Farmers' information behavior

The data showed two ways in which an *information need* could arise in a farmer. Depending on this, farmers chose an active approach in the form of *information seeking* (i.e., by asking for advice), a more passive approach, i.e., exposing themselves to information in an un-targeted way. After obtaining information about pest management strategies, the farmers dealt with the new information in one way or another (*information use*). In the following, we present the findings regarding how farmers developed an *information need*, sought, and used information.

3.2.1. Developing an information need

Two ways of developing an *information need* emerged from the interviews: i) starting a new farming practice and ii) receiving disruptive informational input. Related to the former, one participant explained, for example:

Table 1
Participant characteristics.

Participant number	Interview,farm visit	Approach to pest management	Sex	Age range	Age when started farming
1	I, V	both	m	20–39	n.a.
2	V	conventional	m	40–59	n.a.
3	I, V	conventional	m	40–59	n.a.
4	I, V	conventional	m	40–59	n.a.
5	I, V	conventional	m	60–75	n.a.
6	I, V	both	m	60–75	n.a.
7	V	conventional	m	40–59	n.a.
8	V	conventional	m	n.a.	n.a.
9	I, V	conventional	m	40–59	n.a.
10	I, V	both	m	40–59	n.a.
11	I, V	both	m	20–39	n.a.
12	I, V	both	m	40–59	n.a.
13	I, V	both	m	60–75	n.a.
14	V	both	m	60–75	n.a.
15	I, V	both	f	60–75	n.a.
16	I	both	m	40–59	0–9
17	I	conventional	m	40–59	0–9
18	I	conventional	m	20–39	10–19
19	I	both	f	60–75	10–19
20	I	both	m	60–75	0–9
21	I	both	m	40–59	30–39
22	I	both	m	40–59	10–19
23	I	both	m	60–75	0–9
24	I	organic	f	60–75	10–19
25	I	both	f	40–59	0–9
26	I	both	m	40–59	0–9
27	I	both	m	20–39	0–9
28	I	both	f	40–59	0–9
29	I	both	f	40–59	10–19
30	I	organic	f	60–75	20–29
31	I	both	m	40–59	10–19
32	I	conventional	m	40–59	10–19
33	I	organic	f	60–75	10–19
34	I	both	m	40–59	0–9
35	I	both	f	60–75	20–29
36	I	both	m	20–39	10–19
37	I	both	m	20–39	10–19
38	I	both	m	40–59	0–9
39	I	both	m	40–59	10–19
40	I	conventional	m	40–59	20–29
41	I	both	m	40–59	10–19
42	I	both	m	60–75	10–19
43	I	both	m	40–59	0–9
44	I	conventional	m	20–39	20–29
45	I	both	m	20–39	0–9
46	I	organic	f	40–59	10–19
47	I	both	f	20–39	10–19
48	I	both	m	40–59	10–19
49	I	both	m	20–39	20–25
50	I	both	f	40–59	40–49

Interview (I) indicates an interview being conducted, farm visit (V) indicates a visit to their farm. The approach to pest management is summarized as conventional if there is use of synthetic pesticides, organic if there are alternative strategies applied such as manual weeding, natural pesticides or repellents, both indicates both strategies applied simultaneously. The age is an estimate by the interviewer.

> I was a businessman in timber business (…) but because this job was increasingly becoming hard (…) I got the idea of farming. (…) Now with getting to growing fruits, I had not known about the spraying detail because I was new. (3a)

The second way to develop an *information need* according to the data was to receive disruptive informational input. This occurred when farmers faced a new farming challenge, such as a pest they had not encountered before, and seemed to motivate farmers to seek new information:

> When this pest comes, we get up, and we ask, "What can we do?" This pest is finishing our crops, and it eats the whole maize garden if you do not do anything. (29a)

3.2.2. Information Seeking

Information seeking is the behavior a farmer engages in to come into contact with information, which can include active *information seeking*, or the passive reception of information. It also refers to the various *information sources* a person uses.

(1) Information sources

The qualitative results showed that information reached farmers through both internal (social network of family, friends, and the community) and external sources (dealers of agricultural products, extension workers, labels on pesticide packages, radio, and sensitization programs) (Fig. 2). Farmers reported various non-governmental, commercial, and church-related sensitization programs as sources of information. Further, farmers reported personal

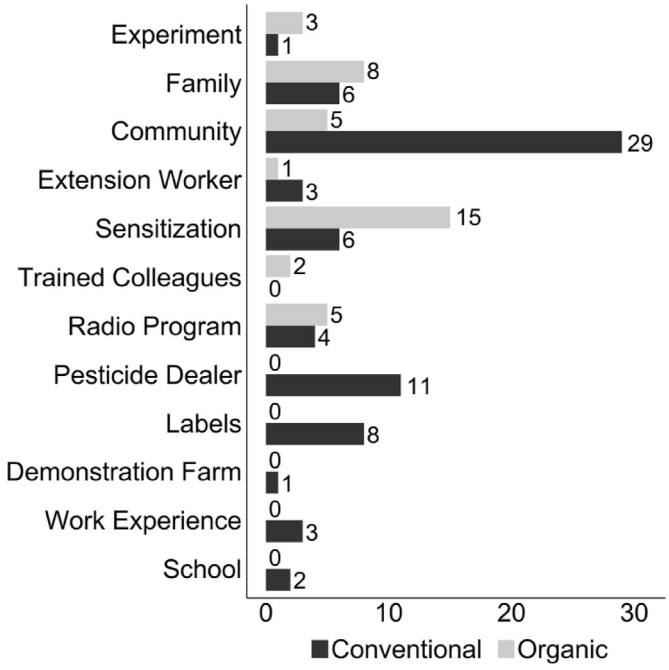

Fig. 2. Farmers' information sources for various pest management strategies. Numbers are absolute because they represent individual, unsolicited statements (n = 46).

experiences and observations during farming as a source of information. One farmer proudly recounted how he developed a pest management strategy by observing his plants.

> About picking those pests, it was myself, after spraying, I used to go back where I had sprayed and started to look at the crop like that maize inside and I would find the pest still inside eating, now I would remove it and get a cup … or a cup … bottle and put it inside, you may pick up to about two cups full of these pests and then I bring them here and burn them and there I am sure that from each crop that I have removed it, the crop remains growing that I have killed the pest. (…) So that knowledge of picking those pests I got it myself so I did not get it from anyone or anyone teaching me and telling me that, "when you go to the garden, you pick those pests like this" No! It was my idea from my brain. (12a)

The information he needed came from his own mind and can be described as an intuition to pick, collect, and burn the pests.

The results of the quantitative interviews support the qualitative findings (Table 2). The most important information source was the community (42%). Others named agribusiness (23%), extension services (17%), sensitization programs (16%), media (16%), and personal experiences (16%) as sources of advice on pest management.

(2) Active information seeking

As shown in 3.2.1, farmers entered a state of *information need* by choice (e.g. when starting a new farming practice) or by necessity (e.g. when facing a new pest). This seemed to influence their motivation to engage in *information seeking*.

To overcome the challenge of dealing with a new pest, conventional pesticide users mentioned seeking information from dealers of agricultural products.

> You ask the shop keeper that my maize has larvae, it is being eaten, it is not growing it is being destroyed so it's not growing so they can tell you that it is this type that can kill that pest. (…) That is where I first go to seek advice. (6b)

This farmer's approach to solving a new farming challenge seemed to be a typical example of respondents' information behavior. He described a setting in which there was a clearly defined situation (his crop was affected by a specific pest) and an obviously desirable outcome (the removal of the pest). The kind of tool that would most likely achieve the goal of removing the pest (a conventional pesticide) was already defined. The farmer only needed one additional piece of information to choose a specific pesticide which he could obtain from a source (the pesticide dealer) that was close to his everyday environment.

(3) Passive information exposure

Not all information transfers regarding pest management strategies were the result of a farmer actively searching for information. Information also passively circulated within the community. Some information was gleaned from observing the behavior of colleagues, as one farmer stated:

> When you see your colleague has sprayed and the elephant grass has dried up you also then have to use it. (34a)

Farmers also came together occasionally and exchanged ideas about pest management, without necessarily having a specific interest in the topic.

> What we mostly talk about, most of the times a person speaks in relation of what he does because my colleague may ask me, "Ehh how are your tomatoes?" And I tell him 'my tomato has got such

Table 2
Sources of advice for pest management by major self-identified pest management practice.

Major Self-Identified Pest Management Practice	Total		Organic		Both		Conventional		*p*-value ($\chi 2$)
	n	%	*n*	%	*n*	%	*n*	%	
Source of Advice for Pest Management	*n = 296*		*n = 88*		*n = 55*		*n = 153*		
Community	126	42.6	30	34.1	20	36.4	76	49.7	0.037
Agribusiness	70	23.6	7	8.0	14	25.5	49	32.0	>0.001
Extension	50	16.9	23	26.1	10	18.2	17	11.1	0.011
Sensitization	49	16.6	22	25.0	13	23.6	14	9.2	0.002
Media	48	16.2	12	13.6	12	21.8	24	15.7	0.420
Personal Experience	47	15.9	18	20.5	7	12.7	22	14.4	0.360

The answer options for sources of advice were multiple choice. However, each participant had to self-identify for only one of the three options for pest management practice. Community entails family, friends, neighbors, and lead farmers. Agribusiness entails input dealers and buyer associations (five organic). Extension entails government bodies, research institutions, and veterinary doctors. Sensitization entails workshops provided by farming associations or international NGOs. Media entails radio, television, and newspapers.

and such a problem.' Then he gives me some advice (…) Yes, those are the issue. (49a)

Our data indicated two other settings, in which information was provided in bundled form, including all the necessary steps and instructions to execute the method. First, information was transferred through socialization. Farmers growing up in a farming environment learned pest management strategies by watching their families:

Since I was born, I could see my father digging the weed. (25a)

In doing so, they learned how to apply these strategies. A second setting for information exposure was sensitization programs. The programs provided detailed instructions about how to apply a certain strategy. This farmer, for example, learned how to prepare alternative pesticides in a sensitization program:

We were told in order to fight against those pests we have to use our local methods, for example like red pepper, tobacco, kawunyira (marigold) and also urine (…) also the ash if you mix all of these they somehow help. (22a)

What is striking throughout the survey is that these programs were received in an almost entirely passive way. Respondents described organizations that came to the villages and brought trainings, rarely meeting the specific *information needs* that a farmer would have in a given situation.

3.2.3. Information use

After obtaining information (actively or passively), farmers decide whether to use it or not. Our interview data indicated that pest management practice were often first tested. If the results were positive, i.e. the crop was thriving and pest was gone, the farmer kept using the method:

When I see my crops with pests, when I consult from others, they tell me, "You go and buy such and such a pesticide, it will kill those pests." When I tried it and found that they die, I just went ahead to use them. (44a)

If the strategy was ineffective, that farmer would look for an alternative. Additionally, some respondents addressed the issue of the reliability of specific information sources, which would affect their decisions to use the information contained in such sources. One farmer described his experiences with an unreliable information source:

Whenever I tried … you know this is a village so they made sure that whoever you went to you would actually see that they are wrongly advising you. That is why I took time to listen to the radio to at least get some knowledge from the radio. Then I also started like whenever I travelled (…) I would try and get some people that I consult. (3b)

3.3. Information behavior and differences in pest management strategies

The second research question addressed potential differences in farmers' information behavior regarding the use of conventional pesticides and organic pest management strategies. Our results indicated that information about conventional pesticides was highly present in farmers' daily lives. It was mentioned as a frequent topic of conversation in the community. Further, the knapsack sprayer, which is used to apply conventional pesticides, is visible all over these communities and functions as a symbol of conventional pesticide use. One respondent stated the following:

I always see people carrying knapsacks. (15a)

Agricultural dealers are a convenient way of gaining information, as the repeated purchasing of products necessitates frequent interactions with the dealer.

The person I would say I seek advice from is that person where I purchase the pesticides. (15b)

As such, the information behavior regarding conventional pesticides mostly occurred within the close proximity to the farmers, without them having to make any extra effort.

In terms of information sources, one striking difference between the two pest management strategies is that there were fewer information sources about organic strategies (Fig. 2). Some information sources were specific to conventional pesticides (e.g., pesticide dealers), while others provided information on both strategies. Regarding conventional techniques, the community was the dominant source, while pesticide dealers were the second most important source. The most frequently stated information sources on organic techniques were sensitization programs (detailed above) and family. One characteristic of these information sources was that they were only present in the farming community at specific points in time. Sensitization programs did not remain in the communities but only happened periodically. Consequently, they may not be available when a farmer had an *information need*. Family members most commonly provided farmers with information when they were children, and more often among organic farmers than conventional.

These results were underlined by the findings from the quantitative survey (Table 2), in which community (49.4%) and agribusiness (31.8%) were found to be the two major sources of advice among farmers identifying as conventional. The community was also a major information source for farmers who identified as organic, though this was true to a significantly lesser extent as compared to conventional farmers ($p < .022$). The second most named information sources regarding organic pest management were extension services (25.0%) and sensitization programs (23.9%).

4. Discussion

The results of this qualitative study provided novel insights into smallholder farmers' information behavior regarding organic and conventional pest management strategies from farmers' own perspective. Along the adapted model of information behavior (Dervin, 1998; Wilson, 1999), our results indicated that farmers developed *information needs* for pest management when starting a new farming practice (e.g. growing a new crop), or when receiving disruptive information (e.g. current practice has adverse effects). In response to this need, farmers actively seek information from sources within or external to their communities, or they are passively exposed to information. Finally, farmers use the new information by first testing new pest management strategies, depending on the credibility of the source.

4.1. Differences in information behavior for organic and conventional pest management strategies

Our results confirm earlier findings indicating that conventional pesticides are the dominant pest management strategy for

smallholder farmers in LMICs (Williamson et al., 2008). Farmers who perceive an *information need* most commonly seek information within the domain of conventional pesticides (e.g., through their pesticide dealers) rather than venturing into new domains (e.g., organic strategies), which are often also unknown to the farmer. For conventional pesticide users, an *information need* for organic strategies only arises when the default pest management option is deemed invalid, e.g., due to a perceived downside, including perceived cost (Boahene et al., 1999) or health risks (Jørs et al., 2018). As such, the emergence of an *information need* can be seen as a "teachable moment" (McBride et al., 2003), i.e., a good opportunity to change current practices. Timing is therefore relevant to interventions among smallholder farmers.

Compared to conventional pesticides, information on organic pest management is not well-integrated into farmers' daily lives, except for the traditional non-chemical practices that farmers were exposed to by their parents as children. This may be attributed to the knowledge intensity and complexity involved in comprehending and applying modern organic farming practices. Feder and Slade (1984) state that if information provides an economic return, then farmers will actively engage in finding such information. This is in line with farmer statements indicating that Ugandan customers are not willing to pay for the added value of organic production.

Providers of information on organic pest management are few, and often only appear at specific times (e.g. sensitization programs). This limits the availability of information on organic pest management at times of need, and hence, their popularity among farmers. This is in line with the findings of (Brown et al., 2018), who found that information sources on conservation agriculture are perceived to be inaccessible and/or to be of limited quality. Our results indicate a gap between the information channels providers prefer to use and those favored by information recipients. Our study also found that providers of information fail to incorporate new technologies that harmonize traditional and modern organic pest management practices. Both results corroborate previous research in Tanzania (Elly and Epafra Silayo, 2013; Msoffe and Ngulube, 2016).

Compared to conventional pesticide users, farmers using organic strategies have a limited network of community peers to rely on for information. A lack of exchange regarding organic strategies may hinder the spread of such practices. This is in line with the findings of Parsa et al. (2014) in that representatives from LMICs defined a lack of collective action within a farming community as the primary obstacle to IPM adoption.

4.2. Implications for practice

The results of our study have four important implications regarding how to successfully convey information about safer and more sustainable pest management strategies to smallholder farmers. First, to promote the use of organic or IPM strategies, our study suggests making information on organic pest management more continuously available in farmers' lives so that farmers can access it when they develop an *information need*. Similarly to pesticide dealers providing information about conventional pesticides, a knowledge broker for alternative pest management could be established within these communities, either in person (e.g. intermediaries (Stefano et al., 2005)) or as part of a platform. Where extension services are available, the awareness thereof should be promoted because farmers who rely on them adopt new techniques earlier than farmers who rely on other information sources (Boz, 2002). Alternatively, social learning can be encouraged, e.g., through introducing role models.

Second, with sensitization being the main channel of information transaction for organic strategies, a general increase in awareness can be attained within a farming community if a critical group size of sensitized farmers is reached. We therefore recommend local, densely focused information dissemination to enhance knowledge about organic pest management in specific communities, as opposed to a geographically widespread campaign among single individuals. Although our findings provide few insights into the content of such campaigns, a shared understanding of social and moral concerns between providers and recipients of information may increase organic farming practices (Mzoughi, 2011).

Third, we recommend utilizing teachable moments in farmers' lives (e.g., when adopting new crops). In these moments, farmers' *information needs* are strong, and they are open to information about alternative pest management strategies.

Lastly, we found that the farmers' most common and trusted information sources regarding pesticides were other farmers within their community, as well as pesticide dealers. These channels can be leveraged to promote previously neglected safe-use practices, such as proper application techniques, container disposal, and the use of personal protective equipment (Alam and Wolff, 2016).

4.3. Strengths and limitations

This study is the first to provide comparative in-depth information about smallholder farmers' information behavior regarding different pest management strategies by applying grounded theory. The qualitative approach revealed novel insights into the complex characteristics of farmers' information behavior and information environments. Future quantitative and experimental research can now provide causal conclusions regarding the information behavioral processes revealed in our study by testing whether they hold for the population of smallholder farmers in LMICs and, potentially, additional farmer populations.

A further strength of this study is the focus on the farmers' perspective (Msoffe and Ngulube, 2016). The question of interest in our study was how farmers naturally acquired information. This emphasizes farmers as actors embedded in the circumstances of their daily lives. Ultimately, it is the farmer who choses and uses information and information sources. Therefore, their perspective is important and will be useful in designing interventions to promote organic or integrated farming.

This study also has some limitations. Foremost, the qualitative approach does not allow conclusions about the generalizability of these findings. The unique strength of this approach lies in providing in-depth insights into farmers' experiences that help build a theory of farmers' information behavior that can later be tested in quantitative surveys, and intervention studies. Further, the results of our study focused on how information is acquired and, to a lesser extent, which information is transferred between the provider and the recipient, or how it is used. While this study therefore has important implications which communication channels should be used to convey information to farmers, we can provide limited information about which information might best motivate farmers to change their behaviors. The behavior-change literature indicates that many motivations may be at play, including risk perceptions, attitudes, social norms, ability, and self-regulation (Mosler, 2012), which have been studied elsewhere (Meijer et al., 2015; Williamson et al., 2003). Lastly, we did not stratify our sample between motives for growing a certain crop, which could give further insights into pest management strategies applied.

5. Conclusions

Our study provided novel insight into smallholder farmers' information behavior related to conventional and organic pest management strategies. We found disparate information environments for conventional versus organic pest management strategies in terms of information sources and their availability in place and time. Our results suggest that providing information on organic pest management strategies in moments when farmers develop an *information need* may be crucial entry points for providing information on organic pest management strategies. Future studies can test the generalizability of this theory of information behavior, and use this information to promote the adoption of organic pest management strategies. This may ultimately help reduce adverse effects of pest management in low- and middle-income countries.

Author contribution

ND: Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Resources, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing.

PS: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Resources, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing.

AA: Project Administration, Resources, Supervision, Validation, Writing – Review & Editing.

SF: Conceptualization, Funding Acquisition, Methodology, Project Administration, Resources, Supervision, Validation, Writing – Review & Editing.

JI: Conceptualization, Funding Acquisition, Methodology, Project Administration, Resources, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing.

Declaration of competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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