Farmer Responsibility and Researcher Learning: Two Sides of the Same Coin ? Reflecting on Five Years of Involvement in Farmer Participatory Experimentation. A Case Study from Tigray, Northern Ethiopia

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Abstract: Participatory experimentation is often forwarded as a suitable approach contributing to natural, human and social livelihood capital. Developing in this way technologies and achieving learning (and empowerment) is important in relation to resilience and sustainability. Distribution of responsibilities among participants is essential for process and outcomes. Learning takes place through interaction of farmers and researchers. However, aspects like momentum, scientific rigor and farmer responsibility are often assumed being at odds. In this case study we explored how distribution of responsibilities affected outcomes for farmers and researchers, for example, in terms of "quality" of interventions and empowerment. In a research project on participatory experimentation in total 16 farmer groups involved and were monitored. In a series of four research cycles (consisting of problem identification, designing experiments, actual experimentation and evaluating outcomes) groups aimed at increased crop yield. Essential control (design and evaluation) was handed over as much as possible to the farmer groups. At the same time, controls, replications and various experimental variables were included to obtain sufficient scientific rigor and to allow analysis of experimental outcomes. In the course of their involvement responsibilities for farmers increased and those of the researchers decreased. Monitoring took place with respect to crop yield achieved, experimental treatments selected by farmers and attitude. Purposive involvement of farmers in all phases of the research resulted in quality of interventions, obtaining experimental skills, trust and commitment: farmers' human and social capital increased. Researchers obtained insight in livelihood complexity, learned how to involve with farmers and to trust farmers' competence and potential as co-researchers. Natural capital increased (yield and functional outputs). Delegating responsibilities to farmers in main stages of participatory experimentation is a major concern to meet its objectives. At the same time, researchers involved in FPE should be sufficiently sensitive to acknowledge and address farmers' livelihood complexity. In this way both stakeholders will learn. Farmers, for example, by becoming more independent and managing their own learning. Researchers by learning at a meta-level about, for example, general agronomic trends and social processes taking place. Exploiting the whole potential of participatory experimentation, therefore, requires a deliberate focus on farmer involvement. In this way delegating responsibilities to farmers will reduce their dependency on external support and facilitation.

Key words: Participatory experimentation, Tigray, farmer groups, distribution of responsibilities

Introduction

Agricultural Productivity in sub Saharan Africa

In sub Saharan Africa (SSA) concerns about food security and crop production are evident (Flora 2010). Agricultural production is therefore considered a main development focus for sub Saharan countries, especially in relation to food security (African-Development-Bank 2016).

To do so, a transformation of existing agricultural systems into more productive ones is pursued, mostly by the use of external inputs. However, until now the intensification paradigm has failed to bring about significant change in SSA (Giller et al. 2011) because agricultural productivity faces numerous constraints, which are diffuse and rooted in local complexity and context.

Constraints can be agro-ecological or socio-economic in nature. Agro-ecological constraints relate to soil, landscape and climate. Socio-economic constraints are connected with issues like land tenure, inflexible markets, technical knowledge and extension support (Ehui and Pender 2005).

Our study area, Tigray in Northern Ethiopia, is exemplary for sub Saharan Africa: crop productivity is low, food-aid essential (Van der Veen and Tagel 2011) and land degradation severe (Ciampalini et al. 2012). Reasons for low crop yields in the northern Ethiopian Highlands are related to unreliable and variable rainfall in combination with problems like hail, soil erosion, poor soil fertility, pests and a low management level (Hengsdijk, Meijerink, and Mosugu 2005).

Abate et al. (2011)) indicated that also in Tigray attempts to improve the local situation failed because many farmers hesitated to implement innovations and approaches that might increase agricultural productivity.

Agronomic Research versus Farmer Research

Agronomic research is important for transformation of agricultural systems and contributed to higher productivity of farming systems through identification of constraints and addressing these by technical solutions and recommendations (Tittonell and Giller 2013).

Recommendations, however, have no universal validity and implementing these recommendations is difficult due to, for example, non-uniform site specific conditions (Giller et al. 2008). Technology is in many cases introduced in a one-size-fits-all format and farmers often hesitate to adopt them and consider them risky (Rigolot et al. 2017). Real impact on crop yield, therefore, still is limited (Giller et al. 2011).

For farmers a permanent need to adapt to changing conditions is required (Boillat and Berkes 2013). Continuous experimentation, therefore, is a way to stay up to date in addressing context and consequently an important survival strategy (Richards 1986, Leitgeb et al. 2014), rather than a risk. Research is part of farmers' daily routine and different authors indicated that farmers are by default experimenters, although not in a formal scientific way (Richards, 1986; Rocheleau, 1994). At the same time, in farmers' experimentation temporal variability is an important concern.

Researchers often use as a starting point the zero-input control, as it allows comparison. Farmers' starting point, however, in most cases is current practice and their comparison of performance is memory based (Rocheleau 1994) rather than relating to a specific time and place: farmers *"reflected in action"* (Martin and Sherington 1997).

Participatory Approaches

One-size-fits-all approaches are often not successful (Kebede et al. 2015) and therefore a careful selection of suitable technologies adapted to specific local contexts is required. Participatory approaches, in which farmers and researchers co-operate, are particularly suitable to achieve such objectives, since context is addressed better than in conventional, more top-down, extension approaches. Involving farmers in the development of recommendations that match local conditions therefore makes future implementation more likely (Farrington 1995). In this collaboration between farmers and different stakeholders complementarity (Sumberg, Okali, and Reece 2003) as well as synergy (Hoffmann, Probst, and Christinck 2007) are considered important aspects. At the same time, indigenous knowledge, of which researchers might be unaware, is mobilized and becoming explicit (Hoffmann, Probst, and Christinck 2007).

Another important outcome of farmers' involvement in participatory experimentation is that they feel more responsible and confident about their own development. Scholars discussing participatory approaches therefore often differentiate between: (1) a functional dimension relating to outputs in terms of, for example, yield, improved practices and sustainability; and (2) a human-social dimension relating to, for example, empowerment (Hellin et al. 2008).

Ways to implement participatory approaches for improving crop productivity are manifold, with each method having its advantages and disadvantages. Examples range from Farmer Field Schools and Local Farmer Research Groups to demonstrations simply showing farmers what-to-do. Initiatives like these are usually framed as participatory experimentation, a form of Action Research in which farmers and researchers co-operate.

Participatory approaches differ in the level of control by the farmers involved and the distribution of responsibilities (Pretty 1995, Biggs 1989). Different authors, for example,(de Souza et al. 2012), stressed the necessity to give farmers a role in the research dealing with their problems, still, providing a serious mandate is, even in the context of participatory experimentation, in many cases neglected.

In my research project participatory experimentation stood central and in order to evaluate its effectiveness an approach was followed in which farmers were unambiguously in the lead: they selected the technologies they wanted to explore within their local context. This more extreme position was selected to allow comparison between the groups and to determine the potential of participatory experimentation.

Roles and Responsibilities in Participatory Experimentation

Farmers and researchers, in general, have comparable objectives in achieving sustainability, increasing crop production and achieving food security. However, in looking for and selecting feasible options to achieve food security and sustainability, differences in backgrounds of farmers and researchers are likely to result in different choices made and therefore different pathways for development. At the same time, communication between farmers and researchers is often troublesome and reference frameworks and perception of risks might be completely different (Ramisch 2014). Farmers often use rationales, different from the ones presumed by researchers and other stakeholders in development work (Ramisch 2012).

Therefore, despite shared research topics, interests of farmers and researchers may diverge. Researchers are, for example, interested in the direct outcomes of the experimentation and if these outcomes allow generalization (Faure et al. 2014). Farmers will consider to what extent research outcomes fit in the in the complexity of their farming and livelihood system. In the context of Tigray, for example, different aspects of these systems all are interconnected: using manure, feeding straw and weeds to livestock, dealing with labour shortage (to look after livestock), using legumes and trees (like *Acacia albida*), frequent ploughing of the land (up to 5 times or more) to secure infiltration.

Researcher often assume the performance of farmer-driven experiments to be limited and to lack momentum (Martin and Sherington 1997). On-farm experiments are often qualified as being unscientific since they lack the property of being controlled and are therefore considered not being reliable: a trade-off between (farmer) involvement and (scientific) rigor (Okali, Sumberg, and Farrington 1994) seems present.

At the other hand, authors like Trouche et al. (2012) indicated that on-farm experiments supported adaptation and validation of technology and are effective in addressing complexity and contextual variability. Obtaining more scientific rigor in on-farm experiments is possible by, for example, including replications, controls and contextual data (Mayoux and Chambers 2005).

In Action Research-settings, where farmers and researchers engage in co-learning (Faure et al. 2014), these different roles, responsibilities and objectives become explicit. Researchers, for example, also have a role with respect to facilitation of the process and introducing novel technology.

In a heuristic model (see Fig. 4) the specific roles, responsibilities and objectives can be labelled with keywords and clustered into domains in which respectively farmers and researchers operate (see also Chambers and Jiggins (1987)).

Participatory approaches potentially increase understanding between researchers and farmers (Anderson, Johansen, and Siddique 2016): this might result in better connections between the domains, boundaries becoming more diffuse and differences between researchers' and farmers' perspectives on sustainable ways to increase crop production becoming smaller. Such differences might be bridged from both sides: researchers, might obtain a more in-depth understanding of local context, while farmers could expand their traditional reference framework, to allow more effective sharing of their views and (traditional) knowledge with researchers (Biggs 2007).

Research Questions

In this case study we explored how distribution of responsibilities within a participatory experimentation framework affected the process and outcomes for both farmers and researchers:

1. How is the process of participatory experimentation influenced by providing a clear mandate to the farmers involved ?
2. What are outcomes achieved for the farmers involved ?
3. What are outcomes achieved for researchers involved ?

Set Up of the Research Project

In my research project I involved in participatory experimentation with farmers with the ambition to evaluate outcomes of participatory experimentation. The project was shaped as a social experiment, in which participants and outcomes were monitored throughout.

In total 16 groups of farmers, distributed over four *woredas* (regional administrative units, see also Fig. 1), were involved in this research project. The actual process started in 2008 with a session in which the farmer groups focused explicitly on the identification of constraints relating to the productivity of their crops. Then, over a period of five years (from July 2009 until November 2014) the farmer groups were involved in four experimentation cycles. In each of these cycles (constituting of a clear design, experimentation and evaluation phase) outcomes were generated that served as an input for the next series of experiments.

From the start onwards I had, in line with e.g. Hellin et al. (2008), a double focus: both technical achievements and empowerment were considered relevant.

The approach selected focused on maximum involvement of farmers; they had a full mandate for all important decisions in the experimentation process and inputs of researchers were essentially restricted to facilitation of the process.

The main tool applied was Focus Group Discussion, in which farmers indeed exerted (almost) full control over the decision-making process. In this way farmers were allowed to control experimentation and to address local context. In addition, Focus Group Discussion was assumed to support social learning by creating a forum for sharing opinions, for negotiation, for distributing responsibilities and making agreements (Kaplowitz and Hoehn 2001).

To characterize and understand the process, roles and responsibilities of farmers and researchers, the actual process and involvement in it were monitored through individual surveys and participant observation. Consequently, my analytical lens in this focused on monitoring functional outputs, human-social outputs, process and context, taking roles of both farmers and researchers into account.

To explore relationships between experimental outcomes and agronomic factors different agro-ecological data were collected, such as for example, rainfall, soil nutrient content and amounts and composition of compost and manure used in the experiments.

In addition, I was interested if the involvement of farmers in participatory experimentation indeed would support contextual relevancy of technologies and practices included.

Study Area

The study area, Tigray, is located in northern Ethiopia (Fig. 1.2). Four locations (*woredas*) were selected in the highlands of central and eastern Tigray. These locations differed in bio-physical context (geology, landforms, soils and local climate). Farming systems are relatively similar and differences mainly related to specific crops used depending on local climate (Frankl et al. 2013). Most of Tigray is considered as semi-arid drylands (Nyssen et al. 2004) with rainfall is distributed over two rainy seasons. Agricultural production in Tigray takes place in mixed farming systems that focus on subsistence crops in combination with livestock (Abegaz 2005).

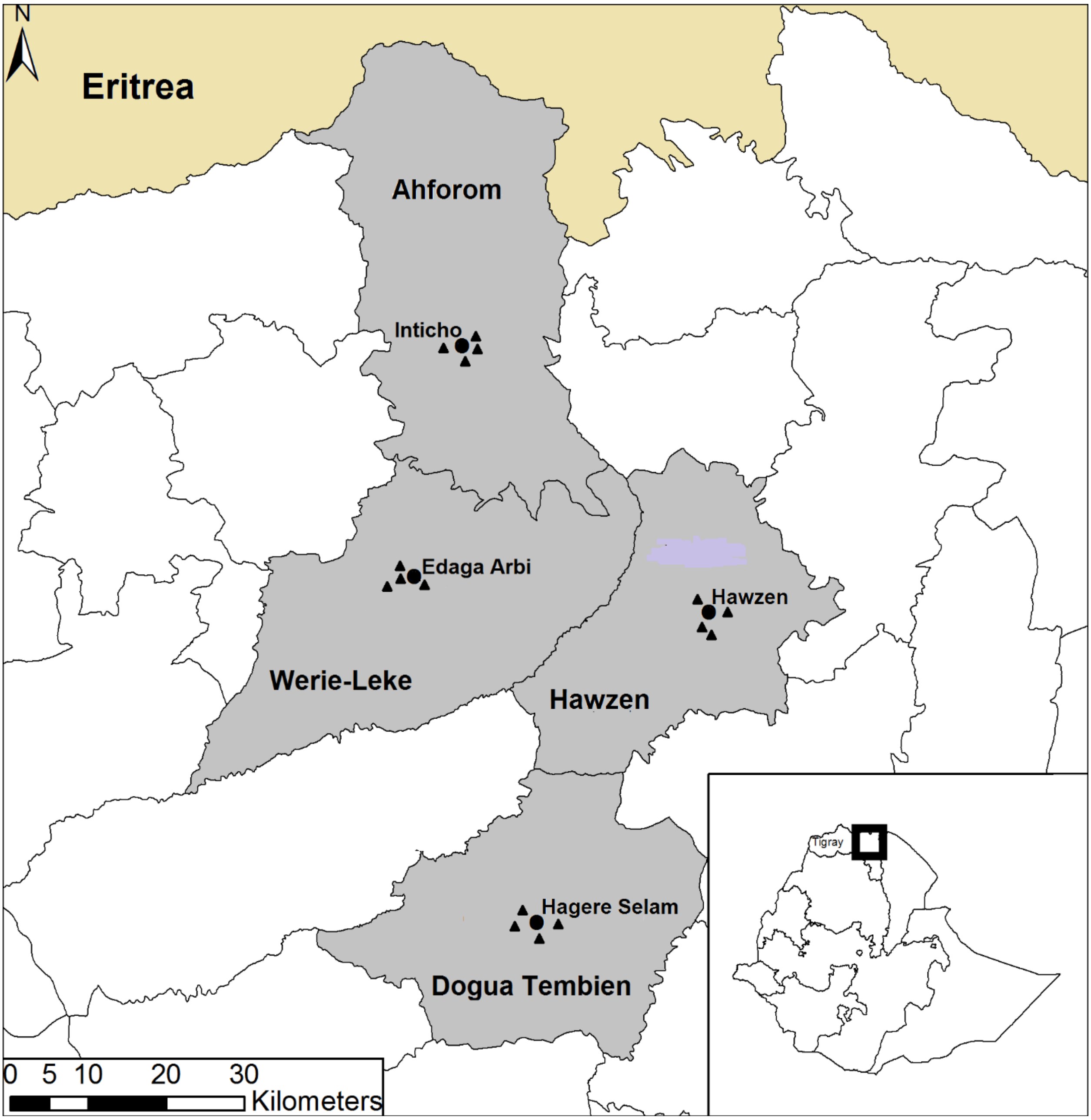

Figure 1: Location of the study area and the involved locations (woredas) in Tigray, northern Ethiopia (dots refer to administrative centres of the woredas, triangles to the experimental sites involved).

Methods and Materials

Participatory Method

Like in most Action Research-settings I followed a series of (connected) research cycles, aiming in this way at progressive learning. Farmers involved in these cycles with the objective to learn about and to develop technologies and practices aiming at increased crop productivity.

These research cycles consisted of specific phases (i.e. problem identification, design of research, data collection and evaluation). In each of these phases choices are made that determine the further course of the research. An essential pre-condition in my research project was farmers having a full mandate in each of these phases. Maximum control over experimentation (analysis, selection) was delegated to the farmers to avoid biased groups due to our inputs. This extreme position was required to make our evaluation more meaningful and is often referred to as "*collegial"* (Biggs, 1989) or "*interactive participation"* (Pretty, 1995). As a consequence our inputs were to be restricted to facilitation and introducing novel technology.

A well-defined protocol for my research was difficult to develop beforehand; the same holds true for a set of well-defined variables to be measured. The actual process was open and I used an iterative approach, but was at the same time guided by a set of *ex ante* identified points of departure:

(1) Long-term involvement in PE was envisaged;

(2) Farmers involved as a group;

(3) Responsibilities were delegated as much as possible to the farmers;

(4) Researchers involved in participatory experimentation primarily concentrated on facilitation of the process.

(5) Farmer dependency on researcher input and facilitation substantially decreased in the course of their involvement;

(6) Impact of local context was assessed by including 16 different sites;

(7) Incentives for farmers were reduced to a minimum;

(8) Throughout the process systematic monitoring of participating farmers took place.

Based on this framework the farmer groups involved were facilitated in a similar, but not identical, way. For reasons of efficiency I concentrated on documenting the process rather than controlling it.

Monitoring of the Process

The process was monitored and described by collecting relevant data on inputs provided, participation of farmers and decisions made within the groups. This data was documented in workshop minutes and field notebooks. Based on our assumption that involvement in the experimentation would result in obtaining specific knowledge related to these experiments, participants were questioned on experiment-based knowledge. For this purpose we used after every research cycle triad tests in which farmers indicated specific combinations of keywords that they considered related (Price 2001). Triad tests have the advantage that a relatively abstract issue can be discussed with farmers having only a low level of literacy. Outcomes were statistically tested (Chi-square test) and contrasted with the combinations that we assumed to be related.

Participant Observation

In the course of our involvement dialogue with participants took place and observations were made on formal and informal occasions such as workshops, field visits, field measurements, community celebrations and harvesting. Such dialogues and observations were recorded in field notebooks.

Reflection on process and Outcomes

During our long-term involvement researchers and field assistants continuously reflected on the process and its outcomes. These reflections were recorded in research diaries.

Results

Monitoring of the Process

The field note books for each of the sites allowed a reconstruction of the (partly) iterative process we engaged in. This resulted in a description of the actual process and how responsibilities were distributed. The outcomes of the triad tests provided an indication of how farmers' knowledge was influenced by their participation in the research.

Description of the Process

The process overall followed the traditional research cycle and responsibilities in subsequent cycles were transferred more and more to the farmers (see Fig. 2). Inputs provided by the process facilitators were limited and restricted to including controls and replications (all years); recommended practices (first cycle); including row treatments (second cycle); including different "tailor-made" treatments (third cycle); and opening up the subsoil (fourth cycle).

First Experimentation cycle. In the problem identification workshops soil fertility measures came out as an issue that was prioritized by the groups. In a next series of workshops in each of the *woredas* farmers from four communities designed an experimental lay-out and selected the experimental field and host farmer. In the workshops some background about experimentation (comparing, replications, controls) was provided by the moderator. Researchers delineated experimental fields (one single field with 15 plots of 3 x 3 m) and implemented the different treatments.

The treatments the farmers included were diverse and included, for example, applications of organic fertilizer. Researchers included, in addition to the design prepared by the groups, recommended application of fertilizer (DAP/urea), a NPK-combination, replications and control plots. In the course of the experiment, field visits were organized and group members and neighbours visited the fields. At maturity grain and straw yield were measured and (provisional) outcomes were provided to the farmers. Farmers helped us in most cases with harvesting and measuring yield.

Second experimentation cycle. The evaluation and design phase took place in the same workshop and farmers used experimental outcomes as an input for their designs; this gave their experiments a systematic character. At the same time these experiences were blended with other insights which resulted in a wide diversity of treatments. Researchers included plots that were sowed in rows; implementing these treatments was difficult because of stoniness. In addition, fields with recommended application of fertilizer and controls were included. Harvesting proceeded as in the year before. Performance of the row-treatments was disappointing.

Third experimentation cycle. Farmers again prepared a design on the basis of the outcomes of the previous year. Some groups changed the field and the host. Researchers included plots with treatments perceived optimal on the basis of the experimentation of previous years. Harvesting proceeded as in the years before.

Fourth experimentation cycle. In the evaluation and design workshop farmers were requested to indicated the treatments they perceived in best and to prepare a design on the basis of the outcomes of last year(s). Researchers included plots in which the subsoil was opened up to promote infiltration and also treatments perceived optimal on the basis of previous experimentation. Some fields and hosts were changed. Harvesting was done as in the previous years, but now farmers also were requested to harvest some of the plots by themselves. Performance of the digging treatment turned out to be disappointing.

Fifth experimentation cycle. For this round farmers again evaluated outcomes of the previous year and prepared on the basis of that an experimental design. Fields and host farmers were in most cases changed. Groups were responsible for implementing the designs proposed and for harvesting. Groups received materials required for conducting the experiments (including equipment for measuring fertilizers and harvesting). Host farmers were visited around harvesting time and interviewed about their achievements.

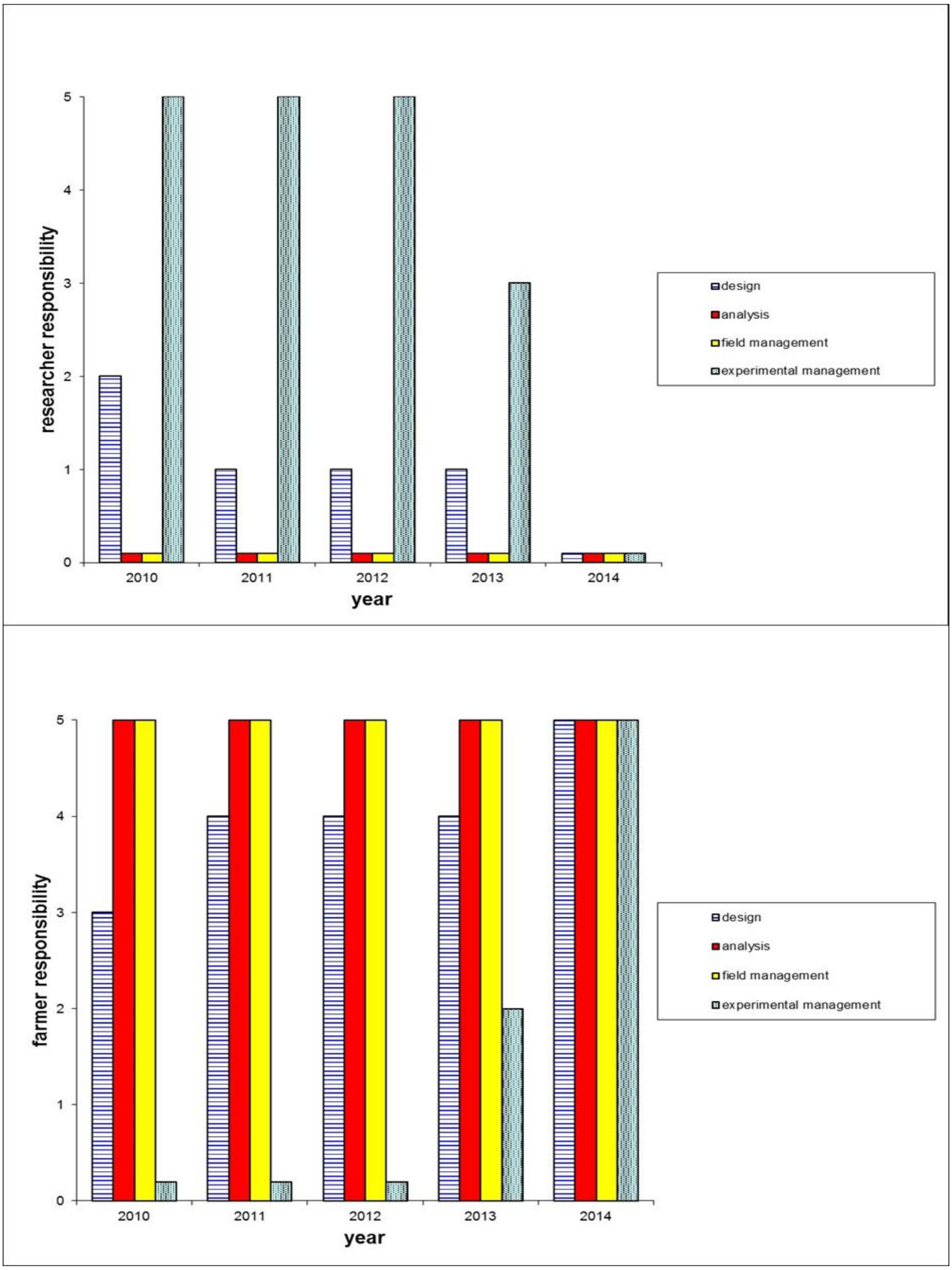

Fig. 2: Estimated responsibility of farmers and researchers for design (striped), analysis (red), field management (yellow) and experimental management (dotted) over the course of their involvement, using an ordinal scale (0 = no responsibility; 5 = maximum responsibility).

Diversity of treatments increased in two ways: by including treatments suggested by the researchers (recommended fertilizer application, sowing in rows, applying potassium) but also by including own ideas (like combinations of inputs). At the same time especially controls and to a lesser extend replications were included (Table 1).

Groups managed in 2013 to harvest part of the plots by themselves, however in two cases outcomes were not reliable. In 2014 four groups did not conduct experiments: two considered the crop planted (sorghum) not suitable for experimentation; two other groups indicated that they needed more guidance.

Table 1: Overall scores of groups with respect to follow up and selecting specific treatments (* = only reliable samples included; # = 12 groups continued experimentation).

Year	2010	2011	2012	2013	2014#
Including recommended practice	14	13	15	16	9
Including replications		11	8	8	6
Including controls		14	12	14	11
Including organic only	14	16	13	12	5
Including combinations	3	9	12	12	9
Including potassium fertilizer		15	12	8	4
Including row			3	3	1
Including digging				0	1
Changing field		6	8	12	7
Changing host farmer			3	6	6
Harvesting*				14*	
Continuation experimentation	16	16	16	16	12

Triad Tests

Based on the triad tests, and although no control group was involved, it appeared that farmers that involved in experimentation learned from their involvement: farmers in most cases selected the combinations assumed to be influenced by their involvement (Table 2). Still, unexpected combinations like "*much straw – many seeds*" and "*rain – DAP*" were also frequently selected. In explaining their choice farmers often provided arguments based on appearance of the crop; for example, in the case of the combination "*rain – DAP*" they referred to greenness.

Table 2 : Scores (as a %) for the different triads farmers selected (assumed combinations are shaded grey; * = significant (*p* = 0.01)).

			Combination (%)		
Year	**No triad**	**Triad A-B-C**	**A-B**	**A-C**	**B-C**
2011	1	manure – compost – fertilizer*	51,3	28,8	20,0
2011	2	urea – compost – DAP*	17,5	60,0	22,5
2011	3	potassium – DAP – manure*	32,5	11,3	56,3
2012	1	urea – manure – DAP*	13,7	65,8	20,5
2012	2	wheat – selected seeds – hanfets*	63,0	23,3	13,7
2012	3	few plants – many plants – row sowing*	14,1	57,7	28,2
2013	1	urea+compost – urea+manure - urea+DAP*	17,4	47,8	34,8
2013	2	faba beans – wheat – lentil*	12,3	84,9	2,7
2013	3	compost – control – urea*	2,7	95,9	1,4
2014	1	rain – urea – DAP*	9,1	37,7	53,2
2014	2	control – urea – DAP*	0	5,2	94,8
2014	3	much straw – many seeds – few seeds*	97,4	1,3	1,3

Participant Observation
The processes and factors involved in participatory experimentation are described by focusing on the different phases of the research cycles.

Problem Identification
Farmers did not identify single factors to which low crop yields could be attributed. Instead, mind maps with different problems and opportunities were prepared. Farmers had full responsibility for the preparation of the mind maps.

Design of Experiments
Farmers primarily used experimental outcomes as an input for their designs, which gave their experiments a systematic character. These experiences were blended with other insights and with tradition, curiosity and farmers' contextual reference framework. At the same time, also elements of systematic experimentation (controls and replications) and treatments relating to novel technology were included in the designs prepared.

Experimentation
The on-farm experiments were diverse and farmers appreciated *"seeing different options in practice"*. Farmers rapidly familiarized with the formal and systematic lay-out of the experiments (delineated plots, measured quantities, controls)..

Evaluation
To allow all (even illiterate) farmers to be involved in the evaluation an easily understandable format (i.e., weight expressed in numbers) was used. Farmers tended to focus on high produce, but in their designs also considered their actual farming system and demonstrated this by prioritizing treatments with a higher straw produce or by including traditional approaches.

Field Visits
Some of the fields were used for field visits in which farmers from the whole location got an idea about the different experiments. In such cases I explained more about the different treatments and about important aspects to be observed. Farmers appreciated this practical exposure.

Reflection on Farmer Involvement
Farmers obviously did not pursue systematic selection of optimal treatments, but instead also focused on having a best fit in their farming system. My observation was that farmers became very confident in their evaluation and at the same time became acquainted to novel technologies, however, in an unconditional way. Once they had seen how the field experiments were organized, this became rapidly internalised.

Furthermore, farmers reported that they had appreciated involvement and ownership in the research. Field-visits to research sites were also considered very important in the context of human-social outputs.

Farmers were, more than I expected, insecure about method of applying fertilizers and the amounts required of these. Applying mineral fertilizers was perceived risky as it required a considerable investment

I observed that different aspects of farmers' identity were changed in a positive way, for example: knowledge, confidence, social trust and responsibility. Using again the conceptual framework of Fazey (2010), I concluded that also epistemological beliefs of the farmers had changed towards using more sophisticated sources of knowledge (i.e. from relying on external sources to knowledge generated through interaction). Such perceptual changes indicated that double loop learning (see Argyris and Schon (1974)), or transformation outside traditional frames of reference (see Duveskog et al. (2011)) took place,

Choices made were, in general, rational and pragmatic and did not necessarily follow mainstream scientific ideas. Farmers employed a complex and original strategy to arrive at a research design, not restricting themselves to pre-defined options. At the same time, however, they were critical and often had reservations, for example, with respect to the use of fertilizers, believing these led to "addiction". Farmers were eager to experiment and even included many untypical treatments. Such out-of-the-box experimentation not necessarily implied trial and error, but instead merged elements of traditional practices and newer insights, for example, the use of ash instead of potassium and row application of compost. Including controls and replications meant that elements of systematic experimentation were becoming important for the farmers.

Controls, initially, were considered waste of produce, later on controls made it possible to compare what zero-input (meaning zero-cost) would yield. Including replications and recommended application of fertilizer also might have resulted of having "space" within the experimental field which typically consisted out of 15 plots.

In the course of their participation farmers became familiar with the structure of the workshop and went on by themselves. Participation was respectful and all group-members involved. In the later workshops they only needed a small hint to go on by themselves, they knew what to do and how to do it. I were surprised by the way they involved in the workshops, being very committed. I observed that participants organized themselves very well. Discussions, in general, were respectful and responsibilities were clear. An older farmer, for example, stood up and addressed the assembly: *"Since I am oldest here, I will thank you …."*. Farmers were proud of their involvement; in their houses I saw sometimes the maps they used during the workshops as a wall decoration (Fig. 3).

Fig. 3: A farmer house showing the charts used in the design sessions as a wall decoration.

Reflection on Researcher Involvement

I was eager to learn about (causal) relationships between experimental outcomes (e.g. yield, response) and agronomic variables (e.g. soil nutrient content, management, rainfall). Most important was the observation that outcome variability (of on-farm experiments) matched well with different descriptive agronomic data (see Kraaijvanger and Veldkamp (2015)). Assumed relationships were, however, not always confirmed and explicit, which was disappointing; interactions between variables were much stronger than anticipated. Modest experimental control through controls, replications and quantification of experimental and environmental variables resulted in considerable scientific rigor and the troublesome trade-off between rigor and (farmer) involvement was to some extent addressed.

Researchers apparently tend to take a positivist stance, whereas farmers definitely took a more holistic perspective and included aspects of complexity. I observed, for example, trends like straw yield preference and combining mineral and organic fertilizers. However, what actually drove them remained unclear and their perspective contrasted with the more formal analytical framework I had in mind. At the same time I started understanding farming system complexity and the impact of different contextual factors on outcomes achieved.

Facilitation, in general, was successful in supporting farmer groups in an unconditional way. However, at the same time it was important to be clear about responsibilities; which was definitely appreciated by the farmers.

In one case, for example, a (host)farmer requested (additional) payment for the use of his field and the likely loss of yield. I, however, explained that I considered the compensation offered reasonable and I requested the farmer in question to consider also his responsibility (since he took this in the preceding workshop). After this discussion the farmer was left to reconsider his point of view, and some 30 minutes later he indeed came to inform that he would take his responsibility for that specific year.

Reflecting on my own role and ambitions, I concluded that I was not that successful in achieving relevant site-specific functional outcomes in the series of research cycles; I failed to address farming system and livelihood complexity and was not able to define clear and relevant recommendations for each of the sites. Initially, I relied on my specific (science-based) reference framework, but later on, just like the farmers involved, started using experienced outcomes more. I discovered that my framework of reference was not always able to fully comply with the reality observed and at the same time, observations made contrasted with my initial assumptions.

My most important learning in relation to the process was that no single factor could be identified and that the process as such was dependent on human-social context. It was clear that blue-print methods would not be successful and that, on the contrary, iterative adjustment of the process was a better way to go ahead.

My case, my role in the process was modest and I instead observed the process from a more periphery position. I learned, in this way, to rely on the capacities and competences and traditional knowledge of farmers and to take their ideas and insights serious.

With respect to the conceptual framework of Fazey (2010), I concluded that my epistemological beliefs had changed with respect to certainty of knowledge: my view became more sophisticated (i.e., from absolute truth and certainty to considering knowledge more tentative and evolving).

Discussion

Distribution of Responsibilities

In Action Research-settings stakeholders have the ambition to arrive at purposeful action and change, but at the same time have different worldviews which are, however, not fixed (Checkland and Holwell 1998). Participant observation and my reflection on process and outcomes indicated that handing over responsibility to farmers was effective in bringing about change (Table 4).

Farmers became competent and confident in managing their experiments and started including treatments on the basis of their own ideas and secured in this way contextual relevancy. Handing over responsibility is essential as (natural) researchers, in general, tend to take a position outside the context; even in Action Research their focus might be more on generalization and understanding (Faure et al. 2014).

Table 4: Overview of inputs provided and outcomes achieved of farmers and researchers involved in participatory experimentation.

knowledge inputs		
Year	*Farmer*	*researcher*
2010	extension, tradition	extension, university
2011	experiment, extension, tradition	extension, university
2012	experiment, tradition	experiment, extension
2013	experiment, tradition	experiment
2014	experiment, tradition	experiment
functional outcomes		
Year	*Farmer*	*researcher*
2010	recommended practices performed well	farmer fields performed well, compost treatments were disappointing
2011	combinations organic and mineral performed well	combinations organic and mineral performed well
2012	combinations organic and mineral performed well	row treatments were disappointing
2013	combinations organic and mineral performed well	digging treatments were disappointing
2014		
human-social outcomes		
Year	*Farmer*	*researcher*
2010	systematic experimentation	insight in effectiveness farming system, dependency on context
2011	confidence and competence	insight in community functioning
2012	confidence and competence	understanding agronomic complexity
2013	confidence and competence	understanding co-operation farmers
2014	confidence and competence	understanding competence

Farmers naturally take a position within their context and bottom-up approaches, therefore, not only relate to the input of the farmers to the experiments but also to the input of context to the process. Still, both stakeholders can learn; important is the appreciation of context by the researchers rather than excluding it for the sake of control (Ramisch 2012).

Farmers, for example, learned through their involvement, not only about crop management, but also with respect to values, beliefs and attitude (Smajgl and Ward 2015). At the same time, I observed that farmers, as was also reported by Cornish et al. (2015), became more independent and started managing their own learning. Researchers learned at a meta-level, for example, about general agronomic trends and social processes taking place. For researchers less responsibilities also meant that their role became more situated at a meta-level and that, most likely, objectives of scientific rigor will become more difficult to achieve.

As a researcher I learned about complexity (functional understanding) but also obtained trust in the performance of farmers and their role. Sharing responsibilities therefore appears a win-win for researchers and farmers.

Process

The iterative process I engaged in was, more than anticipated, effective: groups continued and did not drop-out. Group antecedents were variable and needs to be respected, more than addressed. Participatory experimentation is a context dependent process (Martin and Sherington, 1997) and requires care in designing and implementing it; blue prints are not suitable (Totin et al. 2015).

Different authors highlighted that functional aspects in participatory processes appear to be prioritized (Martin and Sherington 1997), in my case, however, I choose explicitly for empowerment, which potentially might have affected the trade-off between involvement and scientific rigor. At the other hand, farmers and researchers shared their interest in data: farmers highly appreciated the availability of understandable data: it helped them to structure their discussions.

Heuristic model

Outcomes of participant observation and reflection indicated that the domains of farmers and researchers became more connected (Fig. 4). Transfer of responsibilities helped to achieve this: researchers, for example moved from causality towards complexity; farmers started using, next to visual crop appearance, also numbers; researchers included more holistic elements and focused less on recommendations and more on adaptation.

In participatory experimentation farmers and researchers take different perspectives in interpreting and implementing outcomes. External perspectives only make sense for farmers if their livelihood context is also considered. Participation of farmers in the research cycle and mandating them for the design and evaluation phase, resulted over the years indeed in achieving human-social outcomes, for example in empowerment and in farmers becoming more confident. Bridging the domains of farmers and researchers took place from both sides through increased understanding and equality resulting from involvement in participatory experimentation.

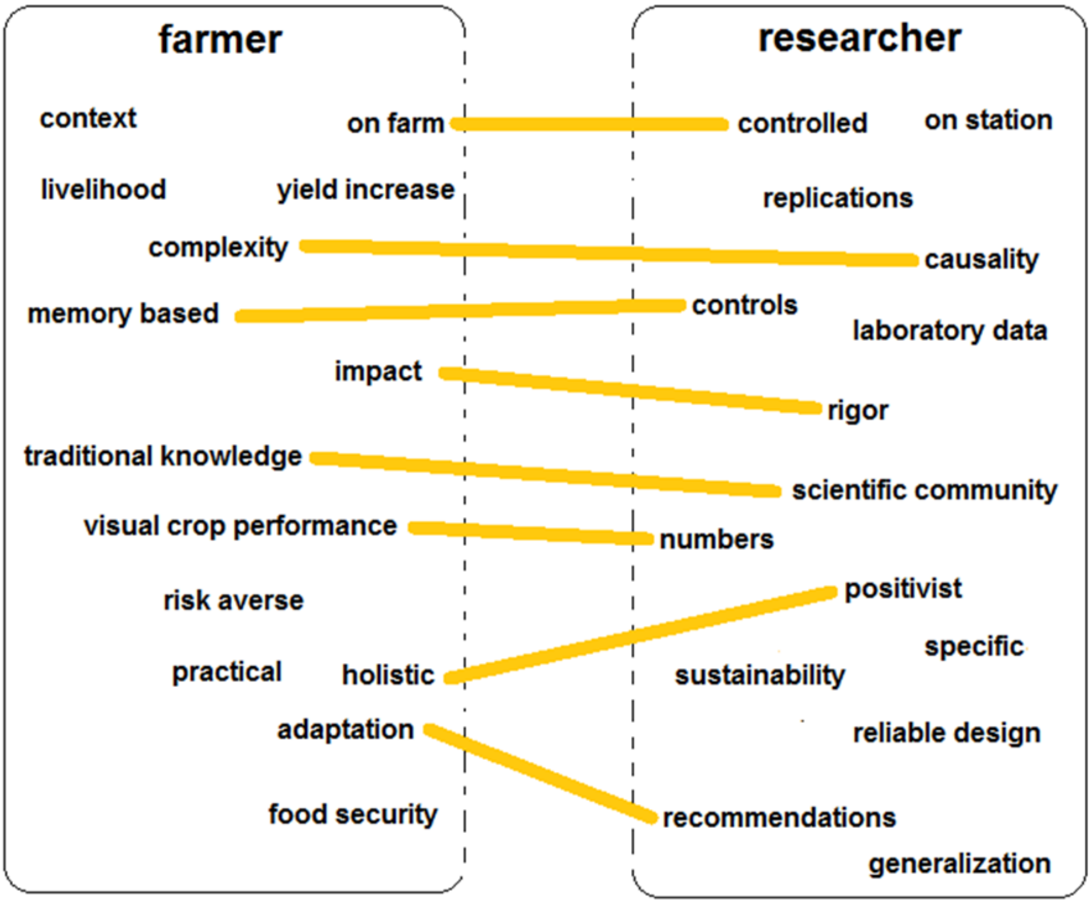

Fig. 4: Domains of farmers and researcher and connections because of involvement in participatory experimentation.

Recommendations

Transition processes in the low input-high risk context of Tigray aiming at farming systems with higher and sustainable productivity will benefit from participatory experimentation in two ways. Firstly, the direct involvement of farmer groups (Dugué et al. 2015) will effectively address local context and preferences and secure diffusion (Darr and Pretzsch 2008). Secondly, the involvement in participatory experimentation will equip participants with social competences that are important in such transition processes.

To arrive at such situations, approaches should be based on open iterative processes in which feedback is essential and responsibilities are delegated in all phases to the farmers participating. Only in this way it is assured that farmers' perspective is reflected in the outcomes achieved. This recommendation fits with the present transformation of extension services in Ethiopia towards becoming less top-down directed (Gebregziaher et al. 2013).

Conclusion

Farmers used responsibilities provided with respect to evaluation and design of experiments and in that process include contextual aspects. Their involvement resulted in confidence and competence which helped them to effectively contribute to the participatory process and reduced the need for facilitation.

Purposive involvement of farmers in all phases of the research resulted in quality of interventions, obtaining experimental skills, trust and commitment: farmers' natural, human and social capital increased. Farmers' learning therefore was not only related to knowing the best way, but also towards confidence in finding the best way. Researchers obtained insight in livelihood complexity, learned how to involve with farmers and to trust farmers' competence and potential as co-researchers.

Delegating responsibilities to farmers in participatory experimentation is a major concern to meet its objectives. At the same time, researchers involved in participatory experimentation should be sufficiently sensitive to acknowledge and address farmers' livelihood complexity. In this way both stakeholders will learn. Exploiting the whole potential of participatory experimentation therefore requires a deliberate focus on farmer involvement. In this way delegating responsibilities to farmers will definitely reduce their dependency on external support and facilitation and contributes to their empowerment.

In participatory experimentation processes at different stages choices are made that have impact throughout. Participatory experimentation therefore should essentially be an iterative process in which small steps and feedback loops are taken. It appears that functional change only will be contextually relevant and sustainable when farmers indeed had the opportunity to fully submerge themselves in the process of participatory experimentation. Exploiting the full potential of participatory experimentation requires a deliberate focus on involvement, especially if empowerment is also to be achieved.

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