Farmers' rationality in soil management: which factors influence implementation of sustainable management practices in soil conservation? – A case study in Germany and Austria

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Abstract: Sustainability in farming practices is of increasing importance in research and society. There has been extensive research on best management practices to mitigate soil degradation. However, invariably the success of practices proposed by scientists and technicians rely on farmers to implement them, ultimately the farmers' actions will determine the soil quality status.

This paper aims to contribute to the provision of insights into farmers' perception of soil and of soil management. Based on this understanding it aims to identify barriers and drivers to adoption of sustainable soil management beyond mere technical aspects. Finally the paper explores the role of soil management in overall farm management by reconstructing the rationality of farmers' decision making in crop rotation and weed management. The study is based on a qualitative approach using open and semi-structured in-depth on farm interviews.

Insights into farmers' decision making in combination with barriers/drivers for implementation of sustainable soil management practices can contribute to a better understanding of what is needed to foster better farm compatibility and thus adoption of these practices.

Keywords: farmers rationality, soil perception, soil management, soil conservation

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Introduction

Technical aspects of sustainable soil management practices have been investigated intensively. Practices such as reduced tillage, contour cropping, cover crops and grass buffers etc. are considered successful measures to reduce soil degradation (Imeson 2006). Also in social sciences, farm-level soil conservation and soil-sensitive land use practices have been addressed in case studies and with region-wide surveys (Currle 1995, Prager 2002, Quast 2011). In most cases the studies disclose a complex set of influencing factors on farmers' behaviour, as it is also reported more generally for conservation issues in agriculture (Siebert et al. 2006). However, these studies also reveal serious difficulties and challenges for farmers' adoption of soil conservation practices. E.g. Prager (2002) shows that farmers cannot easily relate knowledge on environmental components to decision making processes due to the high complexity of soil cultivation management. Currle (1995) underlines the deep rooting of farmers in their specific life-worlds as an explanation to non-adoption. Wauters et al. (2010) state that farmers' intentions towards soil conservation practices are the predominant determinant of their behaviour. The main reason for low adoption identified here is the negative attitude of farmers towards these practices. Fry (2001) and Ingram et al. (2010) explore farmers', experts' and scientists' perspectives on soil erosion and soil cultivation and identify the differences between their views as an important part of the implementation problem. Finally Schneider et al. (2010:332) summarise "implementation of soil protection measures faces the challenge of facilitating interactions between farmers, experts and scientists at 'deeper' level with an awareness of all significant dimensions that characterize the life-world".

It is this dimensional complexity resulting from the interdependent bio-physical and chemical soil processes which makes the understanding of and the dealing with sustainable soil management so demanding and complex (Watson et al. 2002). And in this respect, only few publications are available on farmers' proper knowledge on soil specificities and their experiences with soil management practices. What are farmers' perceptions and foci of interests when observing the soil diversity of their fields, and when monitoring impacts of management measures? In order to improve farm compatibility of suggested management practices and improve their adoption, strategies and measures have to be based on farmers' perceptions, knowledge and rationality (Schneider et al. 2010).

This paper aims to contribute to the provision of insights into farmers' perception of soil and of soil management. Based on this understanding it aims to identify barriers and drivers to adoption of sustainable soil management beyond mere technical aspects. Finally the paper explores the role of soil management in overall farm management by reconstructing the rationality of farmers' decision making in crop rotation and weed management.

Material and methods

Study area and sampling

Data collection was conducted in six different study areas in Germany and Austria. The study areas were chosen according to the EU FP7 Catch-C typology (Hijbeek et al. 2013) which is a combination of the typical farming systems and the agro-environmental zonation. This typology comprises the three agro-ecological variables climate, soil texture and slope with the two farm variables farm specialization and land use. The areas were then selected according to:

Their total area size within the country

The economic importance

The impact on soil degradation

Recognisability within the national context

Sampling of interviewees was conducted via purposive sampling through contact persons. Contact persons were people from advisory services like the Chamber of Agriculture or from Federal Institutions.

Data collection

Between November 2012 and March 2013 in-depth on-farm interviews (n=41) lasting 1 to 3 hours were conducted. Interviews consisted of one open part and one semi-structured part. In the open interviews the farmer was asked to give an introduction of his farm and explain the production steps that have been performed on a given field (the one he had last visited) between the last harvest and the harvest before. Questions then went into details on soil management and soil perception. The semi-structured interviews base on a list of 8 (Austria) to 4 (Germany) proposed best management practices and were structured based on the theory of planned behavior (Ajzen 1991). Behavioral beliefs were conceptualized asking questions about the assumed outcome and the advantages and the disadvantages of specific management practices, normative beliefs were conceptualized by asking for individuals or groups who would approve or disapprove implementing the specific management practice and perceived behavioral control was conceptualized by asking for factors and circumstances that would enable or make it more difficult to implement the specific management practice. The following 3 management practices were included in the analysis of this paper (choice according to quality of obtained data material):

- Non inversion tillage

- Catch crops/cover crops/green manure

- Wide crop rotation with at least 4 different crops in rotation

Triangulation of data was ensured through the combination of first open, second semi-structured interviews and third a visit to the machinery hall at the end of the farm visit, where possible.

Data analysis

The interviews were recorded. The semi-structured parts were re-listened and a list of barriers and drivers of adoption was noted directly from the audio files, sometimes additional information was paraphrased. The open parts of the interviews were transcribed and analysed using content analysis.

Results

Perception of soil and soil management

Farmers use criteria to evaluate the quality of their soils that partly differ from scientific soil evaluation criteria. Table 1 shows the list of criteria used by farmers and the characteristics used to describe the respective criterion. The evaluation criteria are clustered in seven groups according to the area of observation they belong to.

Table 1: Criteria and characteristics used by farmers for soil description mentioned during the open interviews

Criteria	Characteristics	Criteria	Characteristics
Structural traits		**Water**	
Structure	Good-bad	Infiltration	„Soil lets the water flow even during heavy rains“
Cloddiness	No clodds – many clodds	Water storage capacity	Low-high
Crumbliness	Nice and crumbly – stiff, not crumbly	**Soil biology**	
Workability		Biological activity	Very active – dead
Behaviour when cultivated	Structure is resistant, also during rain	Soil-born diseases	Level of occurence
Trafficability	Good-bad	**Soil chemical properties**	
Resistance when ploughed	Degree of force needed for ploughing	Soil organic matter content	Suitable for the soil type, decreasing - increasing
Soil type		Nutrient contents	Well balanced
Grain size distribution	Well balanced	**Other**	
Soil type	Heavy-light soils	Compaction	Level of occurence
		Distribution of soil types within one plot	Heterogenous/homogenous
Observation of plants			
Crops that can grow there	Crop species	Ownership	Rented/own land/other
Yields	High – low - stable		

Farmers use evaluation criteria that are related to the soil traits that are of relevance for the level of success of their cropping activities. Physical soil traits like structure, "cloddiness" or "crumbliness" are mentioned most often in soil descriptions during the interviews. Also the workability of the soil and its behavior during the different cultivation steps is a criterion that is repeatedly used by interviewees. Furthermore, soil texture is used corresponding with scientific soil classifications. The results also show that farmers do not only directly observe soils but also consider the plant development on this soil to draw conclusions on the soil status. The behavior of the soil towards the water balance is also of relevance to farmers and was mentioned in the interviews, as well as soil biological criteria like biological activity or occurrence of soil-born diseases. Further criteria are soil organic matter content, occurrence of compaction, nutrient contents, soil texture heterogeneity within plots, ownership status of plots.

Identified barriers and drivers

It was possible to identify 49 factors that are influencing farmers' decisions for adoption/non-adoption of non-inversion tillage. These factors can be clustered into 16 topics. Below, we will only discuss topics that are of higher relevance (see Table 2), meaning they have been repeatedly discussed by at least 7 different interviewees.

Table 2: Barriers/drivers to the adoption of sustainable management practices mentioned during the semi-structured and open interviews

Factors	**Barrier: -- Driver: ++**	**Times stated**
Machinery		**30**
Availability of machinery	++	6
Special machinery needed	--	10
Farmers have to change system	--	14
Plant protection		**16**
Specific problematic situations	--	6
Pesticides	--	7
Monoculture maize	--	3
Labor organization		**13**
Outsourcing of labor	--	2
Higher efficiency	++	5
Change in processes	+/-	2
Non-conversion tillage as option	++	4
Soil variables		**9**
Too light/ heavy soils	--	3
Evaporation	--	1
Sustain soil structure	++	1
Better loosening and mixing	++	3
Heterogeneity of plots	--	1
Plant residues/ straw/manure	--	**11**
Costs	++	**9**
Weather	+/-	**7**
Social environment	+/-	**7**
Avoid bothering neighbors	--	1
Infrastructure	--	2
Low product prices – risk averse	--	1
No farm successor	--	2
Could convince land owners	++	1
Knowledge/Learning	+/-	**7**
Gain experience	--	4
Exchange with fellows	++	3
Running system – why change	--	1

Source: Semi-structured interviews

Machinery was most often mentioned as a barrier (n=30), specifically the need to change the whole system of machinery equipment to bigger machines or totally other combination (n=14). Likewise the need for special machinery (n=10), especially for seeding is a barrier. Farmers also stated that the availability of machines (e.g. possibility to lend or cheap capital for investment) can foster adoption (n=6).

Plant protection related topics were also mentioned repeatedly as barriers (n=16). These include pesticides (n=7), namely insecurity of availability of certain pesticides, especially glyphosate, or whether the farmer has a critical attitude towards pesticide use. Specific problematic situations (n=6) like occurrence of certain weeds etc. were also seen as barriers. In areas with maize monocultures the wish to prevent problems (e.g. corn borer and diseases) is a barrier to non-inversion tillage (n=3).

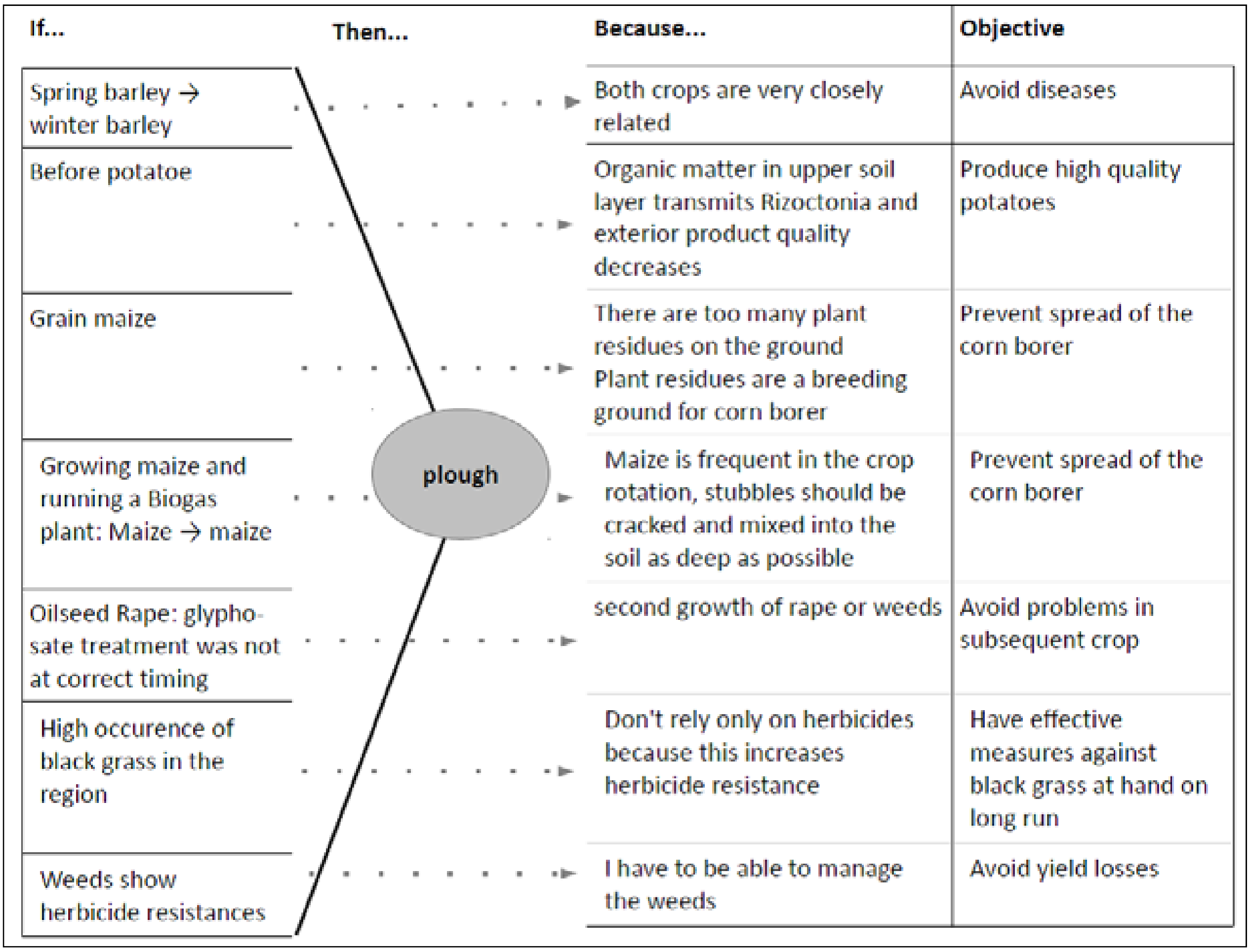
Labor organization (n=13) was stated mainly as a driver to adoption of non-inversion tillage. Other barriers are related to soil variables (n=9) and the management of plant residues/straw/manures (n=11). Further, reduced costs (n=9) and particular weather conditions (n=7) (leading to change in usual routines) were named as barriers or drivers.

Social environmental factors (n=7) include the need to incorporate slurry fast into the soil in order to avoid bothering neighbors (n=1). Additional barriers like small bridges or having to cross the village with heavy machines can constitute barriers (n=2). Attitudes of land owners (n=1), regulated farm succession (n=2) and general market situation (n=1) also are influencing factors. Knowledge and learning (n=7) related issues refer to the possibility to gain own experience (n=4) or exchange with fellow farmers (n=3) as well as a reluctance of changing well running systems (n=1).

Role of soil management in overall farm management: farmers rationality and reasoning

The open interviews show that the perceived role of soil management in the overall farm management can best be described as a variable that has to be controlled in all farm management areas more than a field of management of its own. When asking what topics the interviewees discuss with fellow farmers, soil management is mentioned only as a side issue. As an example, Figure 1 depicts when a plough is used (instead of non-inversion tillage) considering the situation in weed management and crop rotation. It shows in which way the decision whether to plough a given field or not, depends on the management decisions in other management areas. Ploughing or not is then a subsequent choice. The first column depicts the given situation that results from decision making in other management areas. Listed here are only situations that lead to ploughing. Column 3 shows the underlying reasoning why farmers opt for ploughing as the best activity, and in column 4 it is shown which objectives are pursued with the soil management.

Figure 1: Soil management rules



Many of the identified rules are routine rules (e.g. the crop rotation connected rules) but the last three rules (oilseed rape glyphosate treatment, black grass, herbicide resistance) depend on specific observations (e.g. observation of high occurrence of black grass in a given year) and are thus “problem solving rules”.

Discussion

The study provides insights into farmers’ rationality for soil management. Farmers use different criteria to describe their soils that differ from scientific criteria (as stated in Fry 2001), because farmers’ criteria are derived from different levels of soil observations. These results confirm the results of Fry (2001) and Ingram (2010) that farmers possess considerable knowledge about soil and that the differences between the views of farmers and advisors are an important part of the implementation problem. Farmers draw conclusions on the state of the soil by observing the state of the plants (weeds and crops) and not only the soil directly. Here it shows that a lot of tacit knowledge on plant development is involved in soil perception and should be taken into account when designing measures to improve farm compatibility of suggested management practices.

The results of this study additionally confirm how farmers’ intentions towards soil conservation practices are the predominant determinant of their behavior (Wauters et al. 2010). For example the main barrier/driver to non-conversion tillage in this respect is the farmers’ attitude towards chemical plant protection, and especially their attitude towards glyphosate use (see Table 2). This confirms that farmers’ decisions are not only driven by economic rationality as stated by Sattler & Nagel (2010). Costs play an important role, but are named only as one among other factors like associated risks (e.g. plant protection) or social environmental factors (e.g. farm succession), thus these factors seem to be of at least equal importance in farmers’ decision making.

The analysis of farmers’ rationality and the role of soil management in overall farm management shows that farmers do not make a structured soil management plan, but that the decisions concerning soil management eventually depend on decisions in other farm management areas. Interesting is the inner logic that gets evident e.g. in the results concerning maize monocropping. This decision leads to increased ploughing, although from a nature conservation point of view minimal tillage is especially important in maize production. But in the farmers’ perception the threat by the corn borer is a much higher problem than erosion problems. This shows the deep rooting of farmers in their specific life-world (compare Currle 1995 and Schneider 2010) and how they solve their problems based on their perceptions. Soil protecting measures should also link to these perceptions in order to be farm compatible.

Conclusion

Results give insights into farmers’ perception of soils. It shows that farmers describe their soils with evaluation criteria that are related to the soil traits that are of relevance for the level of success of their cropping activities. Farmers base their soil evaluation also on observations of plant development and yields. It gets evident that a lot of tacit knowledge is involved in soil perception and has to be taken into account when designing measures to improve farm compatibility of suggested management practices.

Barriers/drivers to adoption of sustainable soil management could be identified beyond economic rationality including machinery, plant protection, labour organization, soil variables, management of plant residues/straw/manures, particular weather conditions as well as social and knowledge related factors.

Concerning the role of soil management in overall farm management results show how farmers make their decisions based on their problem perception. Hence soil conservation measures should link to these perceptions in order to be farm compatible.

Thus, the results so far show the importance of studying famer's perceptions and rationality and linking these with the analysis of barriers/drivers to adoption of sustainable soil management practices and the role of soil management in the overall farm management. Further studies need to deepen the understanding of these three aspects in order to ensure farm compatibility of proposed soil management practices and to design effective learning processes and knowledge exchange so that eventually farmers are provided with the information they need to opt for sustainable soil cultivation practices.

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