International Research Journal of Agricultural Science and Soil Science Vol. 1(2) pp. 064-069 April 2011
Available online http://www.interesjournals.org/IRJAS

Full Length Research Paper

Local Perceptions of Soil Fertility Management in Southeastern Ethiopia

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Accepted 5 April, 2011

In order to design more appropriate research and development programs geared to improving integrated nutrient management practices, understanding farmer's knowledge is indispensable. However, little effort has been made to capture and characterize the indigenous knowledge of farmers in Ethiopia. This paper discusses the local perception of soil fertility and management practices of farmers in southeastern Ethiopia covered both high and lowland representatives. Twenty farmers who are knowledgeable about soils of the area were randomly selected from each of the three districts to gain insight into different soil fertility management practices, local methods used to identify different soils and to assess the fertility status. Farmers used soil color, texture, water holding capacity, fertilizer requirement (inherent fertility) and workability as a criteria to identify different soil types. However, soil color and texture were commonly used by farmers to describe soil quality. Farmers preferred black and clay soils to white and sandy soils due to their high water holding capacity and inherent fertility. On the other hand, 98% of the respondent perceived the benefit of crop rotation, crop residue management and fertilizer application to improve crop yields though it was impractical owing the escalating price of inorganic fertilizers and crop residues were used as construction material, fuel and source of animal feed. Hence, there is a need to relate farmers' soil management and classification to the soil classification used in research and extension for efficient dissemination of technologies.

Key words: fertilizer requirement; indigenous knowledge; soil classification; soil color; texture

INTRODUCTION

Declining of soil fertility is a fundamental impediment to agricultural growth and a major reason for slow growth in food production in Sub-Saharan Africa (SSA) (Sánchez *et al.*, 1995). Soil fertility decline in much of sub-Saharan Africa has been referred to as an ‘‘orthodoxy’’ where the existence, extent and cause of the problem are accepted without question (Roe, 1995; Leach and Mearns, 1996). Though many of the continent-wide studies indicate that soil fertility is declining, scholars are starting to question the underlying assumptions, evidence, methodologies and scale upon which studies and beliefs of soil fertility decline are based (Scoones, 1997; Scoones and Toulmin, 1999). This problem has often been attributed to the improper utilization and under management of natural resources by the traditional farmers. Due to increased population pressure, farmers are either entirely abandoning the traditional practice of using natural fallow to restore soil fertility, or unable to leave land fallow for long enough for it to be effective. The use of mineral fertilizers is declining as they are beyond the means of most small-scale farmers (Larson and Frisvold, 1996).

Soil fertility decline has become a major concern of policy makers worldwide. In sub-Saharan Africa, the

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issue has taken on a note of urgency as declining food production is linked to subsistence crises (Scoones and Toulmin, 1999). To respond to these concerns, many international organizations are proposing wide-reaching initiatives. The World Bank, for example, has recently adopted a Soil Fertility Initiative for sub-Saharan Africa. The presumption is that soil fertility decline relates to population growth, mismanagement of soil resources, and under-capitalization of farmers (Cleaver and Schreiber, 1994). Sustaining soil fertility therefore, has become a major issue for agricultural research and development in Sub-Saharan Africa (SSA) (Smaling and Oenema, 1997). So far, most research activities concentrate on determining the appropriate amount and type of fertilizer needed to obtain the best yields. This approach emphasized the use of external inputs and expensive technologies and often disregarded the farmers' knowledge and the resources at their disposal (Corbeels *et al*., 2000).

Local farmers have acquired knowledge from generations of experience and experimentation, as they had to adapt their agricultural systems using limited resources under harsh and insecure conditions (WinklerPrins and Sandore, 2003; Saito *et al*., 2006). Hence, in order to design more appropriate research and development programs geared to improving integrated nutrient management practices, researchers need to understand farmers' knowledge and perceptions of soil fertility (Corbeels *et al*., 2000).

Studies from several places in Africa illustrate that farmers have a broad knowledge of soils, which include soil names, soil distribution and soil-plant relationships (Dolva and Renna, 1990; Steinr, 1998; Gray and Morant, 2003). Aubert and Newsky (1949) as cited in Dolva and Renna (1990) described the criteria used by farmers of Sudan and Senegal to identify their soils. However, in Ethiopia the information how farmers understand soil fertility at farm level is minimal. Thus, the objective of this paper is to characterize and understand farmers' perceptions and knowledge of soil fertility in Bale, southeastern Ethiopia.

MATERIALS AND METHODS

The Study Area

Goro, Sinana and Gassera districts were covered in the present study. Goro represents mid and lowland districts (less than 1800 m a.s.l). In this district the rainfall distribution is unreliable and erratic, i.e. variation in start of raining, uneven distribution and intense when it falls. Sinana and Gassera are both highland areas receiving bimodal rainfall pattern with relatively even distribution over both seasons, '*Ganna'* (March-July) and *Bona* (August-December). The cropping seasons are locally named after the time of harvest, i.e. if the crop is harvested in drier period they call the season *Bona* (meaning dry) and '*Ganna'* if harvested in wet season.

Agriculture in all the study areas is predominantly small-scale mixed subsistence farming. At Goro, crop rotation is a common practice. On the other hand, Sinana is predominantly a cereal based monocropping area, while at Gassera though cereals are the dominant crops; they are rotating with pulses and oil crops. Farmers of Sinana and Gassera consider plant disease (especially rust on wheat) as the major bottleneck to crop production. In some cases total yield loss exhibited due to rust problem in these areas. The disease incidence is most likely due to the continuous monocropping of cereals, which favors disease development. Farmers of mid and lowlands, Goro, claim insect pests especially crickets as a major bottleneck for crop production.

The survey work was conducted in three districts of Bale Zone, southeastern Ethiopia, representing different agroecological zones. From each district about 20 farmers who had good knowledge of soils (elder farmers) were randomly selected. Information on farmers' perceptions of soil fertility and the indicators they use to assess the fertility status of their fields was gathered through individual semi-structured interviews, which took place in the farmers' field (interviewee's house). Topics covered included soil fertility management practices and local methods used to assess the fertility status of a field. Information was recorded in a notebook, and a checklist was kept to make sure all topics were covered.

RESULTS AND DISCUSSION

Concepts of Soil Fertility

A scientist assesses fertility from field observations and soil properties determined in the field or laboratory where soil fertility is described according to physical and chemical properties. This analysis gives a deductive picture of soil fertility, but it may not consider limiting factors that the farmers include in soil fertility assessment (Dolva and Renna, 1990). Farmers on the other hand, evaluate and identify soils for practical reasons. They identify soils based on relationships and definitive features. Farmers had the experience of the potential and constraints of their soils.

In view of this, understanding land use history plays a significant role in determining the perception of farmers to their land. The overall land use trend of last five years presented in table 1 reasonably affect the local soil knowledge of farmers in relation to soil fertility and other soil physical properties. Changes in land use in recent decades revealed the expansion of arable land so as to supply agricultural products. However, over exploitation of the land resources could not be maintained in satisfying the welfare of livelihood as the capacity of the land boosting yield per unit area becoming declining over

Table 1. Changes in land use affecting local perception of farmers' as changes in soil fertility in Southeast Ethiopia, Bale

Land use	**Size of holdings over years (ha)**				
	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009
Arable land (ha)	699,513	420,260	352,659	331,154	331,253
Fallow land (ha)	321,539	129,024	94,985	104,496	9,675
Grazing land (ha)	216,694	-	114,188	98,197	64,524
Wood land (ha)	6,015	-	1,298	921	1,459
Other land use	39,865	17,996	16,476	18,421	70,714
Total	1283626	567280	579606	553189	477625

Source: CSA (Central Statistical Agency) report

years which in turn decisive in the interpretation of fertility concept by the local farmers.

The land use that took the lion share of the land mass were grazing land (16.9 percent), fallow land (25 percent) and significantly wood lands (0.005 percent) were converted in large amounts into cultivated lands (Table 1). Grazing land shrank by 3.4 percent and its proportion dropped from 216,694 ha to 64,524 ha of the total land. Fallow land had gone through a similar process of conversion, loosing over 24.98 percent to other type of land use like unused land and arable land.

While pasture and fallow land shrank in both absolute amount and proportion, the land used for cultivation significantly expanded as a result of population growth. According to the regional CSA (Central Statistical Agency) report there was an additional cultivated land estimated at 14.85 percent of the total land exhibited over other type of land use considered. Though the land spread out, the loss in soil fertility from cultivated land was significant and even in some places incapable to execute its carrying capacity.

The changes in cultivated land in quantity had been offset by not only the decline in quality but also the ever growing and unevenly distributed population. The substantial decline in farmland availability had clearly been driven by the forces of population growth. In addition, the worsening situation in parts of the districts was possibly a result of natural hazards and environmental degradation. To better understand the dynamics of changes in cultivated land over time and across space, it would be paramount important assessing the causes or sources of farmland land loss. The combined effect of these all entirely resulted in lack of sustainable production from farmland affecting agricultural activity in a similar fashion in all the districts which ultimately affected the perception of farmers to soil fertility. The information assessed from interviewed farmers clearly pointed out the impact of such negative trend in land use or land management for long time.

In the process of soil fertility evaluation by local farmers from their indigenous perspective, farmers in the study area had common criteria to evaluate and identify their soils. They used soil color, texture, water holding capacity, workability and fertilizer requirement (fertility) as criteria for classification purpose into different groups. Based on these criteria farmers of the highlands categorized their soils into: *Koticha/Guracha*, *Ambocha/dalacha, Gali,* and *Daro*. However, farmers of Goro representing lowlands identified only three soil types; *viz*. Koticha, Dimile/Keyate and Daro (Table 2).

In their critical analysis of how farmers in different settings classify and manage soils, Talawar and Rhoades (1998) also found that farmers see soil productivity as a multi-faceted concept. It included factors such as the soils' capacity for sustainable productivity, its permeability, water holding capacity, drainage, tillage and manure requirement and how it was easy to work. Corbe els *et al.* (2000) in their study at Tigray, Ethipia, indicated that farmers' perceptions of soil fertility are not limited to the soils' nutrient status; it also included all soil factors affecting plant growth. On the other Mitiku (1996) showed that the local soil classification used in Tigray only partly reflected soil nutrient status, as farmers believed that the level of nutrient was the only one of the several factors determining soil's fertility.

According to Corbeels *et al*. (2000), soil color was an important criterion for farmers, as it often reflected the soil's hidden parent material which determines the specific soil characteristics. The texture of the surface layer had some influence on many other soil properties, and gave farmers a clear indication of to whether a soil could be cultivated after the first rains of the season.

Farmers view soil fertility in relative terms and they often relate it with the amount of rainfall in a given year. Farmers ranked '*Koticha' or 'Guracha' (*meaning black soil*)* to be the best soil in terms of productivity in the years of moderate rainfall. Owing its high water holding capacity, this soil gave better yield than other soils in

Table 2. Soil types identified by farmers and their criteria

Soil types	Soil characteristics				Limitations
	Color	Water holding Capacity	Fertility status	Workability	
Koticha	Black	High	High	Difficult	Waterlogging, hardness when dry
Galii/Arada	Variable	Low	High	Very easy	Needs more water
Ambocha/Dalacha	Grey	Medium	Low-medium	Medium	-
Daro	White	Low	Medium	Easy	
Dimile/Keyate	Red	Medium	Medium	Medium	Needs more water

years of low rainfall. However, the major limitation of this soil was sticky when wet and hard when dry; making it difficult to till. On the other hand '*Gali'* was the best in seasons of high rainfall. Its main limitation was low water holding capacity; making it less productive in low rainfall years (seasons). *'Ambocha'/'Dalacha'* soil was the intermediate soil between '*Galii'* and '*Koticha*' in terms of water holding capacity and fertility. The main criterion to classify '*Daro*' was its white color. But, it could be considered as similar to '*Galii*' in terms of fertility. Besides, '*Daro*' soils were previously homestead areas and modified by human beings through the addition of manure and ashes and could be considered man made soils. Gray and Morant (2003) also reported that farmers of Burkina Faso linked soil fertility with specific environmental conditions.

Many development projects had failed because of ignorance of local knowledge systems. Indigenous soil classifications in this regard might provide a cheaper method of understanding soils than formal soil surveys (Niemeijer, 1995). For example, Burkinabe´ farmers had a well-defined system of soil classification that was related to soil texture, color, geographical location, water-holding capacity and nutrient status (Dialla, 1993). In addition, local soil classifications could facilitate communication between farmers, extension workers and researchers (Tabor, 1993).

Similarly, farmers most commonly used soil color and texture to describe soil quality which in agreement with the findings by Barrera-Bassols and Zinck (2003), based on their review of survey results from 25 countries in Africa, America and Asia, revealed that soil color and texture were the most commonly recognized descriptor of soil in most cultures. Farmers of the study area mentioned that black soils were fertile and had high water holding capacity, while white and red soils were most commonly used to infer poor soil. Saito *et al*. (2006) also found similar description of soil color in their study of indigenous knowledge of farmers of northern Laos. With respect to soil texture, farmers preferred heavy soils (clay soils) to sand soils because of their high water holding capacity for the reason that clay soil particles are fine textured by nature and able to hold appreciable amount of soil water especially at times of water shortage than sandy soil whereby the coarse nature couldn't allow water to stay for long rather easily percolate in the soil profile.

Many farmers also agreed that yield had been declined, and attributed this to a general decline in soil fertility. They underlined the importance of different soil management practices to get better yields. The conclusion was corroborated by Elias and Scoones (1999) who found that in Ethiopia farmer perceptions of soil fertility and yield decline were linked to constraints such as land shortages and availability of livestock. Finally, examining farmers' perceptions was important given the increasing use of oral histories to reconstruct environmental change.

Soil Fertility Management Practices

Tillage Practices

Farmers used oxen to pull the local plough '*Maresha*'. Most of the farmers in the highland areas cultivated their land 4-5 times before planting cereals. They argued that increasing the frequency of tillage is one way of improving soil productivity. On the other hand, pulses were planted on marginal lands or with minimum tillage (often ploughed once). They claimed increasing frequency of tillage for these crops could result in lodging and ultimately got lower yield. Though, there were two cropping seasons in Gassera and Sinana, only few farmers cultivated the same piece of land for both seasons. Instead, they divided their land into '*Bona*' cropping and '*Ganna*' cropping land. The main reasons raised by farmers for not using the land for both seasons were shortage of time for land preparation after crop harvest and fear of soil fertility depletion as a result of double cropping. Farmers of Goro on the other hand, cultivated their land once or twice before they planted their crops. They argued reducing frequency of tillage was the best means to conserve moisture.

Crop Residues

As far as crop residue management was concerned, farmers of the study area were well aware of the advantage of returning crop residues to soil fertility. The practice of decomposing crop residues *in situ* was locally termed '*Shemsu*' (meaning decomposition). In addition, farmers understood that if crop residues were not well decomposed before planting, it could compete for nutrient and 'burn' (to mean stunt the growth) the crop. But, only few farmers around 12% in these districts retained most crop residues in their field. This was because crop residues were used as construction material, fuel and source of animal feed.

Crop Rotation

At Sinana most farmers practiced monocropping of cereals (wheat/barley). The easy to mechanization nature of wheat and barley had a major contribution to monocropping of cereals. Lack of crop rotation resulted in the development and build up of rusts, which was the major bottleneck for crop production. The major practice followed by farmers in this area was rotating barley and wheat on the same piece of land.

Unlike to Sinana, farmers of Gassera and Goro were well aware of the benefit of crop rotation and this was 74% and 69%, respectively. At Gassera, cereals were rotated with lentil, field pea, faba bean and linseed. However, at Goro spices were rotated with cereals and chickpea. In both districts farmers applied low rate of fertilizers as precursors were legumes.

Mineral Fertilizers

Farmers in all districts used low rate of mineral fertilizers due to the escalating prices of chemical fertilizers. 87% of farmers applied only 50 kg DAP/ha for cereals. This rate was by far lower than the blanket recommendation (100 kg DAP and 50 kg Urea) for the area. Some farmers practiced dressing the seeds with fertilizer solutions, since uniform distribution of this low rate of fertilizer was difficult with broadcasting. The use of urea fertilizer was very rare and insignificant. Farmers reported that urea fertilizer was necessary only for '*Koticha (Guracha)'* soil. This could be due to loss of nitrogen in this soil owing to leaching and denitrification, as the soil was often waterlogged. In contrary, farmers of Goro claimed that urea burns the crop when rainfall was low.

Fallowing

The study clearly depicted due to the ever increasing population pressure, long term fallowing was abandoned in all the study area. But, farmers understood the benefit of fallowing to restore soil fertility. Rather, the common practice in the area was seasonal fallowing i.e. leaving the land fallow for one or two seasons. This was however, short period for restoration of soil fertility. Allan (1965) reported that the fallow period should not be less than eight years on the best soils. Similarly, Mansfield (1973) claimed the required fallow period for the soil recovery was about 15-20 years.

CONCLUSION

Understanding indigenous knowledge of soils has come to be seen as essential in understanding the local realities of farmer and may be critical for the success or failure of agricultural development. The survey result showed that farmers in the study areas had a good knowledge of the nature and type of soils. They notified their soils based on their experience of the potential and constraints of the soil as they cultivated their land for several decades. Mainly soil color and texture were used as criteria to differentiate different soils in the study. Farmers also suggested about how to manage their soils to sustain the productivity level. However, factors like shortage of land, absence of alternative source of energy or shortage of fuel wood were affecting their decision to practice the different traditional soil management methods. Hence, intervention is required to solve these problems.

Since farmers are the ultimate decision-makers and managers of soils, understanding of farmers view and their soil management is indispensable for exploring opportunities of improvement. Hence, farmers should be considered as a research partners for any technology generation and dissemination regarding soil fertility management. Agricultural research and extension should also be based on the farmers' indigenous knowledge for efficient utilization and adoption of soil management technologies. Therefore, studies relating the farmers' indigenous soil management and classification knowledge to that based on modern research are paramount important in the future.

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