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Farmers' perception of soil fertility problems and their attitudes towards integrated soil fertility management for coffee in Northern Tanzania

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A study was conducted in Hai and Lushoto districts, Northern Tanzania to establish the farmers' perception of soil fertility problems and their attitudes towards integrated soil fertility management (ISFM) for coffee, thereby identifying the appropriate intervention strategies. The study was based on a structured questionnaire involving 126 respondents. Both farmers' awareness of the problem and their attitudes were highly significant (at p<0.01). Age, household size, and adoption of improved coffee varieties, affected farmers' awareness significantly (p<0.05). As for farmers' attitudes, six of the eight predictors were significant (p<0.05). Age, household size, adoption of new varieties and total farm income were highly significant (p<0.01). Age, total land under coffee and total off-farm income negatively affected farmers' attitudes. As farmers get older, they tend to refrain from innovation. Larger farms are likely to exert more pressure on the available organic resources. With multiple farms, distant farms are likely to receive less attention. When off-farm income was considered, multiple ventures compete for the farmers' time, resources and attention. For the two districts, ISFM interventions will make a better impact to younger and more energetic farmers with sufficient lands for commercial coffee production and to farmers who depend largely on this resource for their livelihood.

Key words: Soil fertility, farmers' perception, integrated soil fertility management (ISFM), coffee, Tanzania.

INTRODUCTION

Coffee is one of the major export crops in Tanzania contributing to 23% of the agricultural GDP (Anonymous, 2007). It contributes directly to the livelihoods of over 420,000 farm families and indirectly to over 2 million people employed in the coffee value-chain industry (Carr et al., 2003). Arabica coffee contributes 65% of the Tanzanian total coffee export. The Tanzanian coffee, especially the washed Arabica is one of the best in the world ranked among the rare category of "Colombian Milds" used to blend other inferior coffees.

Coffee is also grown in many countries in East and Central Africa. Other important coffee producers are Ethiopia, Uganda, Kenya, Rwanda and Burundi. According to statistics from International Coffee Organization (ICO, 2011), total production for the six countries was 10.6, 11.4 and 12.9 million bags for 2008, 2009 and 2010, respectively. Tanzania's share was 11.14, 6.2 and 7.08%, while Kenya's share was 5.08,

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5.51 and 6.56%. Ethiopia and Uganda together commanded over 70% of the share for all the three years. The Tanzanian average smallholder coffee productivity per hectare ranges between 250 and 300 kg of parchment which is very low compared to the potential yield of over 1000 kg per tree (Baffes, 2003; Hella et al., 2005). In Kenya, coffee yields were reported to have fallen from 892 $kg.ha^{-1}$ in 1980 to 284 $kg.ha^{-1}$ in 2006, much lower than average yields for Arabica coffee worldwide of 698 kg/ha and yields of 1160 kg/ha in Rwanda and 995 kg/ha in Ethiopia.

Soil fertility degradation is one of the major problems facing coffee productivity in Tanzania. It is defined by Stocking and Murnaghan (2000) as the loss of soil physical and nutritional qualities. It has been an issue of concern throughout the Sub-Saharan Africa (SSA), and cuts across many different soils and crops (Okalebo et al., 2007). In Tanzania, the problem covers all coffee growing zones and all types of coffee growers (Envirocare, 2004). Reports from Kenya indicate that decline in coffee yields were caused by farmers' reluctance to invest in fertilizers (Condliffe et al., 2008) which translates to poor soil fertility.

Integrated soil fertility management (ISFM) has been cited by many authors, including Okalebo et al. (2007), Gumbo (2006) and Raab (2002), as the key approach in raising productivity levels in agricultural systems while maintaining the natural resource base. It is described by Vanlauwe and Zingore (2011) as a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved germplasm combined with the knowledge on how to adapt these practices to local conditions, aiming at maximizing agronomic use efficiency of the applied nutrients and improving crop productivity. Because of the pressing need for global food security, many articles have been published which relate ISFM to the production of annual food crops like maize (Ikerra et al., 2007; Kimani et al., 2007), and rice (Kaizzi et al., 2007), giving lesser attention to perennial crops like coffee. It is no longer wondering then that the role of ISFM for coffee in Tanzania and the socio-economic perception of it have not been studied to any significant detail.

The coffee producing zone of Northern Tanzania comprises four regions, namely Arusha, Kilimanjaro, Manyara and Tanga (a total of 12 districts). Coffee production is both historical and traditional, especially in Kilimanjaro region which was the first to grow coffee as a commercial crop (Maro et al., 2010). Annual coffee production trend for the zone indicates a decline over the years. A number of constraints have been suggested as the cause of this decline. Currently, as reflected during the coffee stakeholders' forum (Tanzania Coffee Board [TCB], 2009), soil fertility degradation has emerged as the most limiting factor. This is however, a very generic perception which needs to be studied in detail by targeting specific locations and farming communities.

The current study was therefore conducted in Hai and Lushoto districts to establish the magnitude of soil fertility problem as perceived by farmers in the two districts, and to establish the baseline farmers' attitudes towards ISFM, thereby identifying the appropriate intervention strategies.

METHODOLOGY

A structured questionnaire was administered to farmers in Hai and Lushoto districts to solicit the farmers' opinion on soil fertility and coffee productivity. The two districts were selected as representative of coffee growing areas of Northern Tanzania, and also representative of soils with contrasting geological backgrounds; originating from volcanic and gneissic parent material, respectively. The coffee areas in the districts were categorized by altitudinal zones: low (900-1100), medium (1100-1400) and high (>1400) m above mean sea level and respondents were randomly selected on basis of having at least 50 coffee trees.

A total of 60 respondents were interviewed in Lushoto and 66 in Hai, making a total of 126 respondents. Generic questions included personal details (gender, age, level of education, position in the household, household size and sources of coffee management information) and farm details (size, number of trees and varieties). Additionally, respondents were requested to give an account of their knowledge of soil problems, source of ISFM knowledge if any, experience in industrial fertilizer use with coffee and negative effects if any, usage of organics (manure, coffee processing by-products, mulches, green manure plants), major and subsidiary income sources and income ranges last season.

The data were processed and analyzed by using the Statistical Package for Social Sciences (SPSS version 16) (SPSS Inc, 2007). The analysis involved computations of mean and frequency, together with two linear regressions: one on farmers' appreciation of soil fertility problem and the other on farmers' attitude towards ISFM.

Defining the variables

The degree of appreciation of soil fertility deterioration as a problem (aP) was described as a mean of two ratings, one qualifying the farmers' knowledge of their soils (0, 1 and 2 for no, slight and basic knowledge, respectively) and the other qualifying farmers' understanding of soil related problems (0 = no idea, 1 = could identify other problems, 2 = could identify crop-related problems and 3 = was able to identify nutritional disorders). The ratings were categorized as 0, 0.5, 1.0, 1.5 and 2.0 for unaware, slightly aware, moderately aware, sufficiently aware and fully aware, respectively. The assumption was that, as noted by D'Emden et al. (2005), awareness of a problem is a motivator in devising (or adopting) problem-solving techniques.

Attitude towards ISFM (α) was described as a mean of eight ratings including the two stated above (R_{soil} and R_{prob}) and six others. R_{ind}, R_f and R_b are dummy variables qualifying whether a farmer uses (1) or does not use (0) industrial fertilizers, farmyard manures or coffee by-products, respectively. R_{fp} and R_{bp} at the scale of 0, 1, 2 and 3 are the ratings qualifying farmers who do not process because they do not use farmyard manure or pulp, those who use the organics raw without any processing, those who just heap the material to stabilize in the open, and those who compost the material in a pit. R_{train} is a rating that qualifies whether and how many times last year a farmer received training on ISFM (an aggregate of four topics – soils, ISFM, identification of nutritional problems and making of organic composts): 0 = no training, 1 = trained once, 2 = trained twice and 3 = trained more than twice. The resultant ratings varied between 0 and 2, and were clustered at maximum values in terms of readiness to adopt ISFM interventions

Table 1. Description of clustered ratings.

Cluster	Maximum value	Description
0	0	Minimum likelihood of adoption
0.1-0.5	0.5	Will need a lot of time and conviction to adopt
0.6-1.0	1.0	Will need some time and conviction to adopt
1.1-1.5	1.5	Will need little time and conviction to adopt
1.5-2.0	2.0	Will adopt readily.

Table 2. A comparison of the selected predictors per district.

Predictor	Unit	Means	95% C.I		Notes
			Lower	Upper	
A	Years	60.83	58.37	63.29	Coffee is a crop for old people
ED	Rating	1.23	1.09	1.37	Majority primary, fewer ordinary
HS	Rating	2.37	2.21	2.54	2 to 8 persons per household
FEX	Years	30.08	27.3	32.86	People with immense coffee exp.
LS	Ha	0.8	0.68	0.92	Typical smallholders
CV	0=no, 1=yes	0.33	0.24	0.41	Adoption of 24-41%
FI	Rating	9.13	8.39	9.86	600,000 to 900,000 TZS
NFI	rating	1.83	1.05	2.6	Maximum of 200,000 TZS

as shown in Table 1.

Descriptive statistics

The two variables aP and α were exposed to descriptive statistics following the models of Nkamleu (2007) and Zhou et al. (2008) which involved physical counts and percentage frequency, and were compared per district.

Regression modelling

The defined variables aP and α were separately exposed to a linear regression model as functions of demographic predictors (age and level of education of the household head, the size of the household, farm and non-farm income) as defined by Doss (2003) and farm related predictors (such as land size and types of coffee trees). Both models used the same predictors as shown in the example below which represents aP

$$aP = b_0 + b_1A + b_2ED + b_3HS + b_4FEX + b_5LS + b_6CV + b_7FI + b_8NFI + \ell$$

Where: b_0 represent the constant, b_1A = coefficient related to age, b_2ED = coefficient related to level of education, b_3HS = coefficient related to household size, b_4FEX = coefficient related to coffee farming experience in years, b_5LS = coefficient related to total coffee land size, b_6CV = coefficient related to coffee varieties (whether improved varieties are adopted), b_7FI = coefficient related to farm income last year, b_8NFI = coefficient related to non-farm income last year, e = random error of prediction.

Each of the eight predictors were then assessed in terms of the significance level at which it influences the farmers' awareness of soil fertility decline as a problem on one hand, and the farmers' readiness to adopt ISFM interventions on the other.

RESULTS AND DISCUSSION

The significance of predictors per district

The eight selected predictors were compared per district (t-test) and were all highly significant ($p < 0.01$). Means and their 95% confidence intervals are shown in Table 2. Average age of respondents was around 60 years, implying that coffee is still held by old people. This observation was in line with Morris and Venkatesh (2000), Mateos-Planas (2003) and Tiamiyu et al. (2009). Education level was mainly primary, with fewer cases of post-primary education. Majority of households have 2-8 persons, which is average for many Tanzanian households (ILFS, 2001; Kamuzora, 2001). With the mean coffee farming experience of 30 years, it implies that most of the coffee farmers in the study districts have immense experience in their business, and their perception of soil problems and best ways to manage soil fertility should be considered in devising appropriate ISFM packages (Douthwaite et al., 2002).

Land size of mean 0.8 ha (CI 0.68-0.92) implies that the people we are dealing with are truly smallholders who are resource-poor, and therefore, the ISFM packages should have that in mind. An average of 33% of the respondents have adopted the new improved varieties released by TaCRI. This implies that there is still an uphill task for TaCRI and other coffee stakeholders to promote these varieties among farmers.

The distribution of farm and off-farm incomes in

Table 3. A summary of farm and off-farm incomes in 2009/2010.

Category	Farm income (%)	Off-farm income (%)
None	0	74.6
<0.3 m	14.4	11.0
0.3 – 2.0 m	76.0	9.6
>2.0 m	9.6	4.8

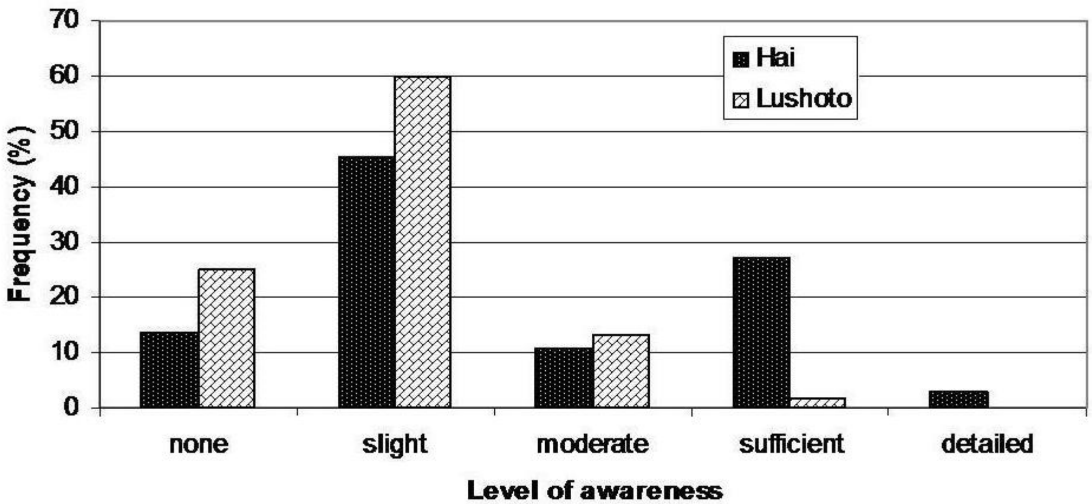

Figure 1. Distribution of awareness of soil fertility decline as a problem.

2009/2010 is given in Table 3. Farm income appears to be fairly normally distributed with the majority ranging between 0.3 and 2 m Tanzania Shillings (equivalent to US$ 190-1250 at the current exchange rate of TZS 1,600 per US$). With off-farm income, 74.6% of the respondents reported to have none, thus depending entirely on the farm for their livelihood. Those who have subsidiary off-farm incomes (25.4%) may portray variable pictures as regards farm attention. For some, it may be a deterrent factor, keeping the farmer busy with the off-farm ventures at the expense of the farm. For elite farmers however, a subsidiary off-farm income can act as a buffer against fluctuating coffee prices, and/or a stimulant in adopting good agricultural practices (Karki and Bauer, 2004).

The distribution of variables per district

The frequency of farmers' awareness of soil fertility degradation as a problem is shown in Figure 1. The majority of respondents from Lushoto are either unaware (25%) or slightly aware (60%). On the other hand, 9% had sufficient awareness and 0% fully aware. In Hai, the unaware and slightly aware groups were 13.6% and 45.4%, respectively, while 3.0% are fully aware, 10.6% moderately aware and 27.3% sufficiently aware. The results appear to correlate well with the respondents' levels of education, whereby 6.67% in Lushoto and 25.53% in Hai reached post-primary education.

As for attitude towards ISFM (Figure 2), the distribution of respondents in Hai was fairly normal, with a peak at 50% for moderate attitude group, tailing at very low (1.5%) and very high (7.6%). The Lushoto distribution was rather irregular with only one interesting feature that the percentages that have moderate and high attitudes are equal at 40% each, therefore constituting the bulk of the sample. The percentage of respondents with moderate to very high attitudes was 84% for Hai and 92% for Lushoto, implying that ISFM intervention will have greater impact in the latter.

Analysis of regression models

A summary of the regression models for problem appreciation and attitude towards ISFM is given in Table 4.

Problem appreciation

The regression model for problem appreciation (aP) was

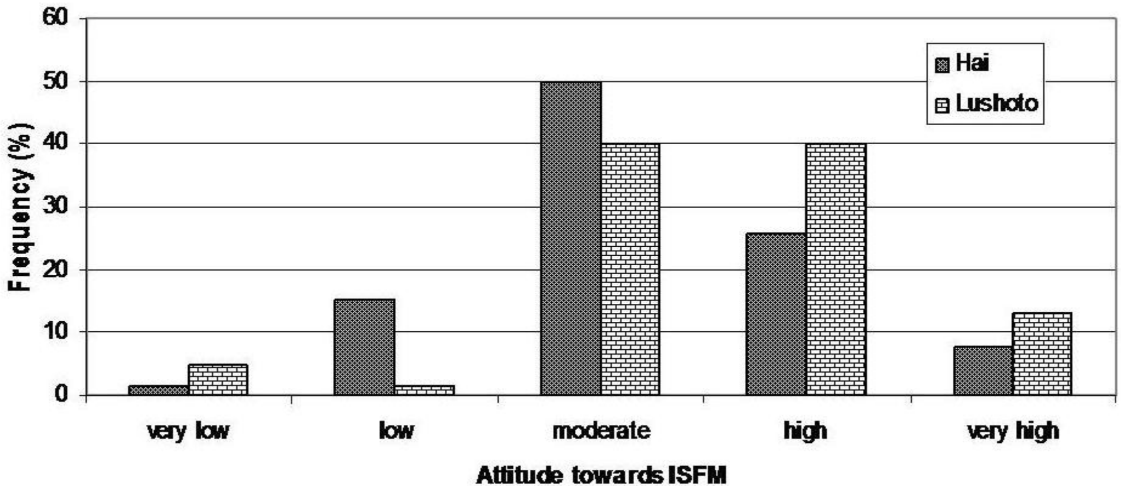

Figure 2. Distribution of attitudes of farmers towards soil fertility management.

Table 4. Model summaries for problem appreciation and attitude towards ISFM.

Predictor	Problem appreciation			Attitude towards ISFM		
	β	t	Sign	β	t	Sign
Age	-0.163	-1.597	0.113	-0.350	-3.103	0.002
Level of education	0.041	0.447	0.656	0.113	1.319	0.190
Household size	0.251	2.761	0.007	0.235	2.785	0.006
Years growing coffee	0.079	0.763	0.447	0.288	2.530	0.013
Coffee land size	0.165	1.743	0.084	-0.185	-2.083	0.039
New varieties adoption	0.228	2.553	0.012	0.422	5.022	0.000
Farm income last year	0.087	0.956	0.341	0.227	2.659	0.009
Off-farm income last year	-0.110	-1.159	0.249	-0.145	-1.654	0.101
(Constant)		1.747	0.083		3.953	0.000

highly significant (at $p<0.01$) even though there was a rather poor correlation (Adjusted R^2 of 0.133) among the parameters entered. Only household size and adoption of improved coffee varieties were highly significant ($p<0.01$), while age was significant at $p<0.05$. Age was seen to negatively affect the farmers' awareness of soil fertility problem as older people tend to become more passive about what happens in their farms (Truong and Yamada, 2002). The rest did not show any statistical significance; including level of education. The relationship between household size and problem appreciation is not very clear. However, if family members are trained in diagnosing unusual characteristics in the field, the bigger the hosehold size, the more likely it is for problems to be identified.

During the survey in Lushoto, 75% of respondents who had slight to sufficient awareness about soil fertility degradation also had considerable information about soil fertility management. Similar observations had been noted at Makueni District, Eastern Kenya by Kimiti et al. (2007). Their indigenous technical knowledge (ITK) showed that "mishai" trees (*Albizzia maranguensis)* contribute in restoration/maintenance of soil fertility. Other ITKs learnt during the survey include the "tugutu" bush (*Adhatoda engleriana* Lindau, family Acanthaceae) which is also medicinal (Moshi et al., 2005). It has been tested with other crops and found to have high nutrient release potential. A formulation for making liquid fertilizer from their leaf extract was described. This opens an avenue for further research on the nutrient content of the"tugutu" leaves and ways in which this, where present, can be integrated in the local ISFM packages for coffee.

Attitude towards ISFM

The regression model was also highly significant (at $p<0.01$). Of the 8 parameters used in predicting α (attitude towards ISFM), 4 were highly significant (Age, household size, adoption of new varieties and total farm income) and 2 were significant at $p<0.05$ (land size and coffee farming experience). These observations are partly in line with those of Jamala et al. (2011). Level of education showed positive but insignificant influence on farmers' attitudes. The significance of education level in affecting adoption was reported by Barungi and Maonga (2011), Tiamiyu et al. (2009), Ono (2006) and Ani et al. (2004), which does not appear to be true in the study areas.

Age, total land under coffee and total off-farm income had negative B, β and t values. Age showed to negatively influence the capacity and willingness to adopt new approaches including ISFM. This is in line with the observations by Nzomoi et al. (2007). The fact that total coffee land showed negative relationship with attitude towards ISFM (contrary to the observation by Karki and Bauer, 2004) can only be explained in two scenarios: larger farms exerting more pressure on the limited amounts of available organic sources of nutrients like FYM; and farmers having multiple farms, some a distance away from their households, thus precluding efforts to use organic sources in those distant farms (Vanlauwe and Giller, 2006; Nkamleu, 2007). Off-farm income showed negative influence on farmers' attitudes, observations that are in line with those of Adolwa et al. (2010). If this source of income contributes substantially to the total family income, the farmers' attention gets skewed from coffee towards the other ventures.

Conclusions

The results from this study led to the following conclusions:

The perception of soil fertility degradation as a problem in the study areas is influenced by several household and farm variables. Among the eight predictors, only the age of household head, the size of the household and adoption of new improved varieties showed to be responsible for variation in perception, with the former having a negative impact. More farmers in Hai are aware of soil fertility problem than in Lushoto.

Attitudes towards ISFM showed to be highly influenced by age, household size, adoption of new varieties and total farm income; and moderately influenced by total land under coffee and number of years spent by the household head in coffee business. Again here, age showed a negative relationship to attitude towards ISFM, implying that older people are usually skeptical in adopting new approaches. The percentage of respondents with moderate to very high attitudes was higher for Lushoto than Hai.

In the two districts, ISFM interventions will make a better impact to younger and more energetic farmers with enough land for commercial coffee production and who depend largely on this source for their livelihood. These are the ones who can easily adopt improved varieties and good agricultural practices, including ISFM practices like mulching, composting of farmyard manure, coffee pulp and other field residues. Long-term plans should be to encourage younger people to take up the coffee farming business, build the capacity to monitor the soil fertility regularly and give quick, site-specific recommendations. Also, promotion of the improved coffee varieties among farmers should continue.

Future directions

This is the first in a series of studies aimed at developing an effective and spatial ISFM decision support system for coffee in Northern Tanzania. It has effectively opened up our knowledge of soil fertility problems as perceived by farmers. The next steps will be to explore the extent of the problem through soil fertility surveys, and then decide on the right ISFM packages that will make impact in the study areas. The findings will be useful for TaCRI in planning for ISFM intervention in the Northern Zone.

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