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ORIGINAL ARTICLE

Subsistence farmers' experience and perception about the soil, and fertilizer use in Western Ethiopia

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ABSTRACT

Low crop productivity, mainly caused by low soil fertility and absence of efficient and sustainable soil fertility management practices, is a major constraint contributing to food shortage in Ethiopia. Though several limitations restrict its use by small scale farmers, the use of inorganic fertilizers has been suggested as one of the best approaches to address this problem. This study was conducted in Western Ethiopia to assess the perception of farmers regarding the status of the soil, soil fertility problems and important factors in the use of inorganic fertilizer using semi-structured questionnaires. The result showed that farmers identified reddish brown and black soils as the predominant types of soils in the survey area. Most farmers were aware that the fertility of the soil and the amount of fertilizer used in their farms were declining over the last five decades. The highest proportion of farmers reported to have problems in obtaining fertilizer at the right planting time. In addition, the high cost of fertilizer was identified as one of the most important factors that hindered the use of inorganic fertilizer by farmers. The majority of respondent farmers identified farmers' cooperatives as the major supplier of fertilizer. However, the highest proportion of respondent farmers (30.6%) rated the quality of service of farmers' cooperatives as bad. Hence, as a major supplier of fertilizer in Ethiopia, farmers cooperatives need to improve the quality of their service in supplying fertilizer to farmers.

Keywords**:** Farmers' perception, PRA, inorganic fertilizer, low soil fertility, acid soils

INTRODUCTION

High population growth (at the rate of 3.3%), recurrent drought (Deressa and Hassen, 2009), and low productivity of crops, poses a huge challenge to Ethiopian agriculture in meeting the food demand of the country. This wide gap between food production and food demand can be narrowed down through intensive agriculture (Wallace and Knausenberger, 1997). However, intensive agriculture requires the use of high amount of inputs, such as inorganic fertilizers and pesticides, along with responsive varieties. Despite, the availability of inorganic fertilizers in the market, the level of use of such inorganic fertilizers by subsistence farmers of most Sub-Saharan African (SSA) countries, like Ethiopia is very low, compared to the amount used by developed nations (Lynch, 2007).

Sub-Saharan Africa uses very low levels of inorganic fertilizer. According to Lynch (2007), average inorganic fertilizer use in North and South America is 100-300 kg ha $^{-1}$, while the use in Africa is 21 kg ha^{-1}, and only 10 kg ha $^{-1}$ is used in SSA. It has been estimated that there has to be at least 18% annual increase in fertilizer use in SSA in order to boost food production to meet the food need of their growing population (Wallace and Knausenberger, 1997). Such a low use of inorganic fertilizer coupled with poor soil fertility is one of the critical food production constraints in most developing countries, particularly in Western Ethiopia.

Most of the soils in Western Ethiopia are acidic with pH ranging from 5.5-6.7 (Van Straaten, 2002). According to Wortmann *et al.* (2003), the availability of nutrients in the soil is highly influenced by pH. Soil nutrients, such as nitrogen, potassium, calcium, magnesium, sulfur, zinc, molybdenum and most importantly, phosphorus (P) are deficient on acid soils. The deficiency of P is mainly due to aluminum toxicity, which prevents the uptake and translocation of P by the plant, and aluminum and iron fixes the available P, and convert it into unavailable form (Rao *et al.*, 1993). Since, Western Ethiopia receives a high mean annual rainfall of above 1300 mm; there is a high loss of soil fertility, through erosion and leaching. In most cases, cereals are produced in mono-crop condition for several consecutive seasons (Tulu *et al.*, 2008), which has contributed a lot to the degradation of the fertility of the soil. Hence, unless efficient soil fertility management practices are designed and implemented, the productivity of such soils will remain poor.

The acidity problem of the soil can be partly improved by the application of lime (Rao *et al.*, 1993; Wortmann *et al.*, 2003). However, lime application alone without the application of inorganic fertilizers at the right time and rate cannot solve the fertility problem of the soil. On the other hand, the use of inorganic fertilizer has remained very difficult for most subsistence farmers of developing countries, due to high price of fertilizer, which is beyond the purchasing capacity of farmers in the region. Jayne *et al.* (2003) reported that the high price of fertilizer could be attributed to high costs in transaction; transportation, handling and storage; taxes and fees; and excess profit resulting from lack of competition among different fertilizer marketing enterprises.

According to (Aklilu, 1980), government policy, which includes: agricultural price, credit, taxation and investment policies, has a great influence on the adoption-diffusion of fertilizer. The author opined that three variables i.e., profitability, risk and extension service are the main determinants of adoption-diffusion of fertilizers. Reduction in farm gate price of fertilizer could be achieved through minimizing these different components of farm gate prices, along with policy considerations (Aklilu, 1980). Besides, there are several other reasons, which are believed by farmers as the major bottlenecks that hinder the use of inorganic fertilizer at planting time and in the recommended amount. Hence, assessing these perceptions helps to understand the actual problems that soybean producing farmers are facing, and to design future strategies to enhance the use of fertilizer for soybean production. It also helps to design relevant research approaches, and facilitate researchers-farmers communication (Desbiez *et al.*, 2004). Moreover, the level of lack of awareness of farmers on some of the most important agricultural principles and practices can be revealed through such assessments. This will help to design awareness creation programs and trainings to fill the knowledge gap.

Participatory rural appraisal (PRA) techniques have previously been employed to assess farmer's perception on soil quality, soil fertility problems and indigenous soil fertility management practices (Erkossa *et al.*, 2004; Elias, 2002; Desbiez *et al.*, 2004). Farmers in Caffee Doonsa, a small watershed in the central highlands of Ethiopia, identified and ranked 12 types of soils; based on the use (Erkossa *et al.*, 2004) and seven types of soils in Kindo Koisha district of southern Ethiopia (Elias, 2002). Desbiez *et al.* (2004) reported that farmers in mid-hills of Nepal identified 62 indicators of soil fertility, which were divided into five major related classes i.e., soil characteristics, crop performance, agricultural management, environmental factors and biology. Crop production was used by farmers as a means to judge the fertility of soil in South West Niger (Osbahra and Allanb, 2003). The Soil Quality Institute of USDA has developed two soil quality assessment tools, which can be used by farmers and field workers (Ditzler and Tugel, 2002). Elias (2002) emphasized the importance of farmers' involvement in the systematic soil quality assessment. Through their long experience of agricultural practices, farmers have developed various techniques that can be used to detect the decline in soil fertility. The soil fertility decline indicators used by farmers includes: change in weed biomass and species; changes in soil color, and thickness; reduced growth and color changes of crops and low crop yields in climatically good seasons (Elias, 2002). The author also reported that 94% of the respondent farmers believe in the presence of soil fertility decline in the past several years. Osbahra and Allanb (2003) reported farmers' perception of declining soil fertility by 80% of the respondent farmers. Farmers associated the decline in the fertility of the soil with the addiction of the soil to fertilizer, loss of its fertility, and the soil become sick and power less (Elias, 2002). Although it is difficult to explain what is referred by farmers as to the soil get addicted to fertilizer, and sick, the authors suggested that this might have association with long term use of DAP fertilizer, which might have caused the acidity of the soil, as according to Smaling *et al*. (1992), DAP is a strong acidifying fertilizer. Wortmann *et al*. (2003) reported that all nitrogen, phosphorus, and sulfur fertilizers can cause acidity. These authors also reported that the acidity caused by nitrogen fertilizers i.e., anhydrous ammonia, ammonium nitrate, and urea is similar; however, it is higher than ammonium sulfate, di-ammonium phosphate (DAP) and mono ammonium phosphates (MAP).

Despite, the importance of farmer's perception assessment, there was no such study conducted in Western Ethiopia. Thus, recent and adequate information is lacking on farmers perception on the types and status of soils, the trend and constraints of fertilizer use in the region. Therefore, the objectives of the study were:

1. To assess smallholder farmer's perception on the different types of soils that exist in the study area, and the fertility situation of the soil
2. To determine factors for inorganic fertilizer use in Western Ethiopia

MATERIALS AND METHODS

Study sites

The study was conducted in three sites (Jimma, Illubabor, and Assosa) of Western Ethiopia. Some agro-ecological characteristics of these sites are described in Table 1. Jimma and Illubabor, are categorized as tepid to cool, humid mid highlands, while Assossa is categorized as hot to warm sub-humid lowlands (MoA, 1998). Maize is the dominant cereal crop in all the sites. Besides, tef, sorghum, millet, wheat and barley are the most important crops produced in Western Ethiopia, in the respective order of importance (Efa and Shibru, 2005). Currently, there is strong effort to scale up soybean production and consumption in the survey areas. Consequently, soybean is emerging as an important legume crop in the region. The three sites receive high rainfall. In such high rainfall areas, basic cations usually precipitate, and iron oxides become abundant; resulting in acidic reddish brown soil (Singh and Gilkes, 1992; Shengli *et al*., 2004).

Table 1. Agro-ecological characteristics of the study zones

Study sites	*AEZ	Altitude (masl)	Location	Annual mean RF (mm)	Annual mean temperature		Soil type
					Min	Max	
Jimma	H_2	1750	$7^0 46'$N 36^0E	1754	11	26	Reddish brown
Illubabor	H_2	1550	$8^0 3'$ N 30^0E	1835	12	27	Dark red brown
Assosa	Hot to warm sub-humid lowlands	1550	$10^0 0'04$N, $34^0 0'57$E	1316	16.8	27.9	Reddish brown

H_2- Tepid to cool humid mid highlands, AEZ=Agro-ecological zones of Ethiopia (MOA, 1998)

Data collection and statistical analysis techniques

At the start of the PRA, 30 key informant farmers were interviewed; and the outcome of which helped in designing the main questionnaire. The semi-structured questionnaire was administered to 67 respondents belonging to eight peasant associations (PAs) in Assossa; 57 respondents from 12 PAs in Illubabor; and 62 respondents from 13 PAs in Jimma. The questionnaires were administered in Jimma and Illubabor zones by five researchers, selected from different disciplines of Jimma Research Center, who have good knowledge of the local language (Afan oromo), and English. Similarly, the questionnaires around Assossa zone were filled by five researchers from different disciplines.

Types of data

Some of the major socio-economic features of the interviewed farmers were collected. These includes: altitude of the respondent's residence, which is the GPS reading for the altitude of the interviewed farmer residence; distance from all-weather road and development agent (DA) center, farmers estimates of the distance of their residence from all-weather roads, and DA center. Age of the head of the household and family size was also part of the data collection. Data collected also included: types of soils i.e., farmers identification of the different types of soils in the survey areas; change in the fertility of the soil over time that is farmers assessment of the fertility of the soil over the past 1-5 decades; indicators of the change in the fertility of the soil that is the criteria's farmer are using to detect the changes in the fertility of the soil. Farmer understanding on the importance of different causes of soil fertility decline was assessed using rankings; problems that hinder the use of commercial fertilizer were also assessed. The trend of inorganic fertilizer use by the farmers, which was the quantity of fertilizer farmers are using since 1995; farmers view on the impact of long-term use of inorganic fertilizer on the fertility of the soil; the various sources of fertilizer; whereby farmers purchase fertilizers, and farmers evaluation on the quality of service they obtained from the major supplier of fertilizer in the country i.e., farmer's cooperatives.

Data analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS) software. Descriptive statistics, such as graphs, cross tabulations were used to present the out puts of the analysis. The rank frequency of farmer's ranking of the different causes of the decline in the fertility of the soil was summarized, and the overall rank of these causes was determined by calculating the total points i.e., multiplying the rank frequencies by the relative weight of each rank (1^{st} Rank= 5 points, 2^{nd} Rank= 4 points, 3^{rd} Rank= 3 points, 4^{th} Rank = 2 points, and 5^{th} Rank = 1 point).

RESULTS

Socio-economic characteristics of the respondent farmers

The proportion of male and female respondent farmers was 89.9% and 10.2%, respectively. The residences of respondent farmers were located at altitudes ranging between 1242 and 1989 masl (Table 2). The maximum distances of the respondent's house from all-weather roads, market and DA center were 12, 36 and 12 kms, respectively. The maximum age of the respondents was 76, while the minimum was 20. The largest family size was 18, while the smallest was three, and mean family size was seven.

Table 2. Some socio-economic features of the respondent farmers

Socio-economic features	N	Minimum	Maximum	Mean	Standard Error	T test against the mean (two tailed)
Altitude of the respondents residence (masl)	96	1242	1989	1604.8	27.48	0.02
Distance from all-weather road (km)	182	0	12	.9	.12	0.000
Distance from the market (km)	184	0	36	6.8	.47	0.000
Distance from DA center (km)	185	.01	12.00	1.4	.14	0.000
Age of head of the household (number of years)	186	20	76	41.9	.87	0.000
Family size (count)	186	3	18	7.1	.20	0.000

Major types of soils in the survey area

Farmers in the survey area reported four major types of soils based on color, (black, reddish brown, brown and gray), and two types based on texture (clay and sandy (Fig. 1). The most commonly recognized soil types in the study sites were reddish brown (95.6%), followed by black soil, which was identified by 85.8% of the respondents. Based on texture, two types of soils i.e., sandy and clay soils were identified by 10.9 and 6.6 % respondents, respectively.

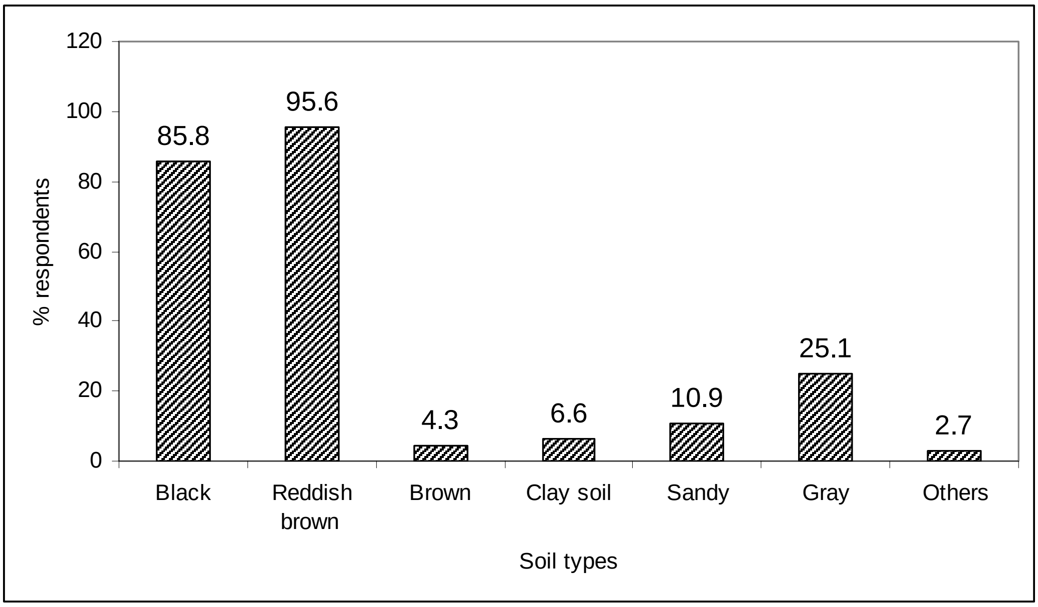

Figure 1. Types of soils recognized by farmers in the study areas (N=186)

Change in soil fertility over time

Most respondent farmers (87.4%) believed that the fertility of the soil declined in their farming experience (the last 1-5 decades) (Fig. 2). It is only 9.3% of the farmers believed that the fertility of the soil increased in the farming experience of respondent farmers. Some of these farmers justified that soil fertility decline or improvement is determined by the way the soil is handled and the soil fertility management system used.

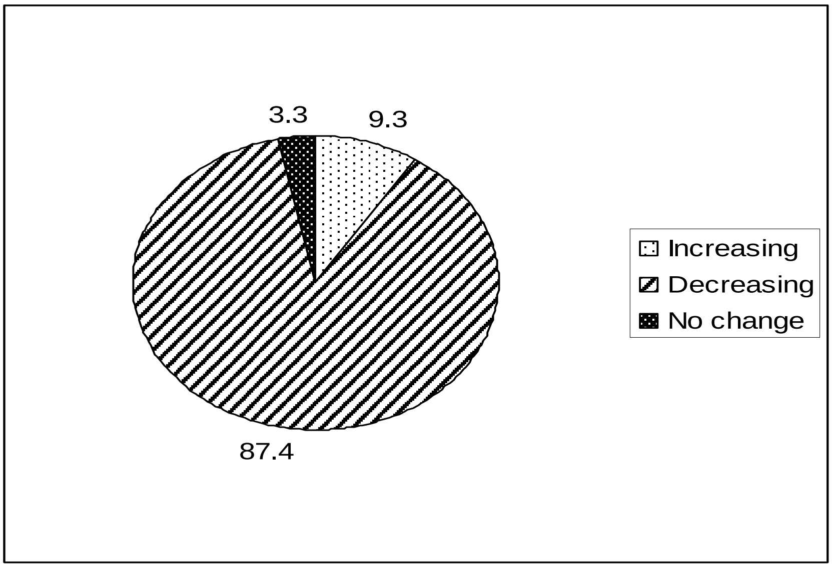

Figure 2. Farmers perception on the change in the fertility of the soil over time (N=183)

Indicators used by farmers to detect change in soil fertility

Most farmers (85.9%) use poor crop yield in climatically good season as a means of knowing the decline in the fertility of the soil. The other three i.e., change in soil color and thickness; reduced growth and change in crop color; and shift in weed biomass were also important indicators of change in the fertility of the soil with respective percentage respondents of 67.2, 63.8 and 85.9 (Fig. 3).

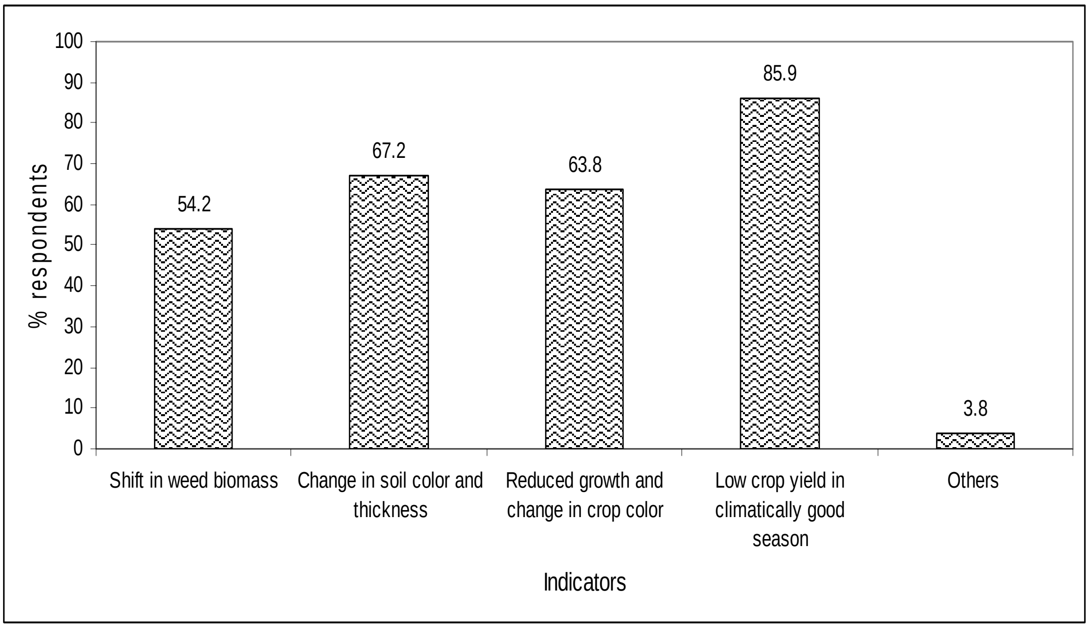

Figure 3. Indicators used by respondent farmers to detect the change in the fertility of the soil (N=186)

Farmers' knowledge on the major causes of soil fertility decline

Almost all respondent farmers (99.5%) replied that they know the cause of low soil fertility problem. Farmers ranked soil erosion as the number one cause of low soil fertility problem with 515 points (Table 3). Long term mono-cropping ranked second (471 points) followed by poor soil fertility management practices (382 points). Dependency of the soil to fertilizer was ranked last with total point of 186.

Table 3. Farmers rank frequency, total points and rank of the major factors causing low soil fertility problem (N=126)

Factors	Rank frequency 1	2	3	4	5	Total points	Rank
Soil erosion	53	39	23	11	3	515	1
Dependency of the soil to fertilizer	6	5	11	18	67	186	5
Long term mono-cropping	40	34	32	18	3	471	2
Producing heavy feeder crops (such as sorghum)	12	21	28	38	14	332	4
Poor soil fertility management practices	18	30	33	28	17	382	3

Problems associated with use of inorganic fertilizers

Majority of the farmers (76.6%) indicated that they can not get inorganic fertilizer at the right planting time. It is only 23.4% who are able to get inorganic fertilizer at the right planting time. The main problems associated with fertilizer access were assessed and the result indicated that although, high cost of fertilizer and absence of credit were highly emphasized by Assossa farmers with respective percent respondents of 82.8 and 43.1, the problems were also critical at Jimma and Ilubabor (Table 4). The untimely availability of fertilizer has got high and nearly the same magnitude across the three locations Jimma, Illubabor and Assosa with respective percentage respondents of 65.4, 56.1 and 65.5. Problem in distribution system is uniquely higher at Jimma (38.5%), while lack of purchasing capacity is at Assossa (27.6%)

Table 4. Problems associated with farmers not obtaining inorganic fertilizer at the right time (% respondents in each location)

Factors	Locations: Jimma (N=52)	Illubabor (N=57)	Assossa (N=58)
Access for credit	25.0	22.8	43.1
High cost	51.9	61.4	82.8
Timely unavailability	65.4	56.1	65.5
Lack of response	34.6	10.5	17.2
Problem of availability in the required amount	38.5	15.8	32.8
Problem in credit returning system	21.2	1.8	5.2
Obtaining fertilizer at the right planting time is not a problem	21.2	17.5	17.2
In-efficiency of the officers	26.9	19.3	29.3
Supply related problem	17.3	15.8	29.3
Distribution system	38.5	19.3	12.1
Reason unknown	5.8	19.3	17.2
Lack of purchasing capacity	3.8	7.0	27.6
Others	5.8	7.0	3.4

Trend of fertilizer use since 1995

The proportion of farmers who didn't apply fertilizer at all on soybean were 10.7%. Among the farmers who were applying fertilizer on soybean, 53% replied that the amount of fertilizer use in their farm has declined since 1995, where around 32.8% of farmers started using fertilizer (CSA, 1996). Despite, the high cost of fertilizer and problem of availability at the right planting time, large percentage (39%) of respondents has increased fertilizer use on their farm (Fig. 4). The farmers, who have consistent use of fertilizer were lowest in proportion, i.e., 8.0 %, respectively.

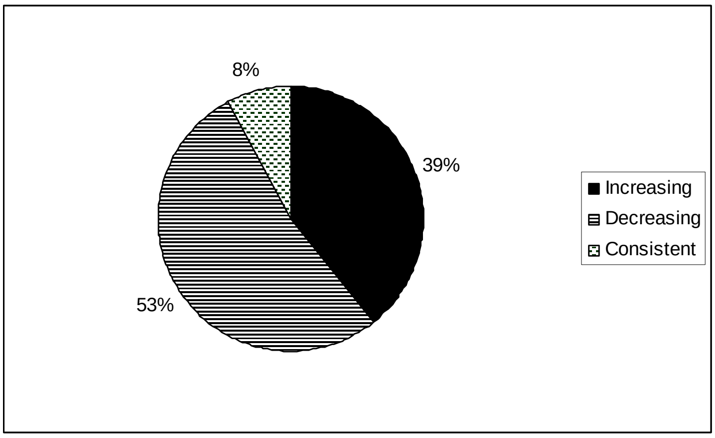

Figure 4. Trend of inorganic fertilizer use by farmers in percentage of respondent farmers (N=186)

Farmers' perception on the impact of inorganic fertilizer on the fertility of soil

Assessment was made on what farmers believe in the impact of long term use of inorganic fertilizer on the fertility of the soil. Most of the interviewed farmers (66.1%) believed that long term use of inorganic fertilizer reduces the fertility of the soil. It is only 21% of the respondent farmers who believed that use of inorganic fertilizer increases the fertility of the soil, while 11.3% replied no change on the fertility of the soil (Fig. 5).

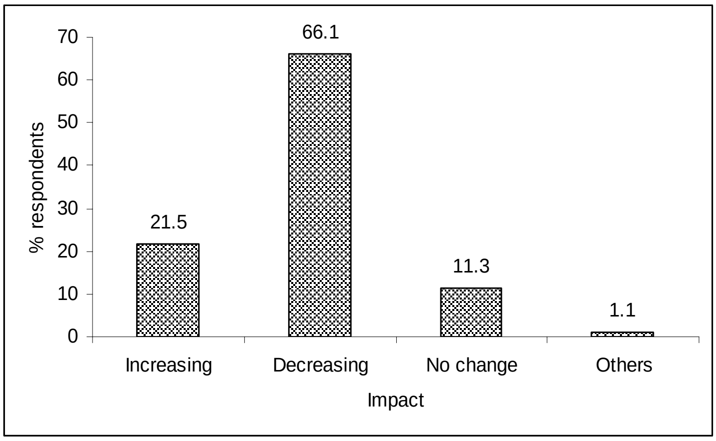

Figure 5. Farmers' perception on the impact of long term application of inorganic fertilizer on the fertility of the soil

Sources of inorganic fertilizer

Most of the respondent farmers (69.9%) chose farmers cooperatives as the primary source of inorganic fertilizer (Fig. 6). The Bureau of Agriculture and small private traders were the next important sources of fertilizer, for 20.2% and 18.6% of the respondent farmers, respectively. Most respondent farmers (47%) believe that there is no easy access to inorganic fertilizer. However, among the different sources of fertilizer, farmer's cooperatives and governmental sources were identified as easier sources of inorganic fertilizer by 14.9 and 13.3% respondents, respectively. The proportion of farmers replied that market and small private traders are easier sources of fertilizer, and those replied that there is no problem of access were equal (8.3%) (Fig. 7).

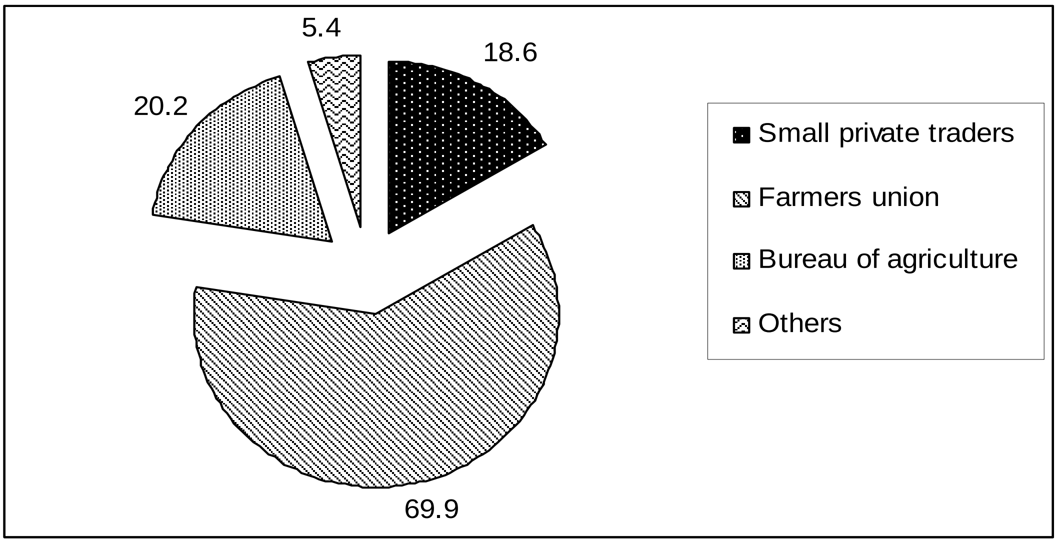

Figure 6. Major sources of inorganic fertilizer used by farmers (in terms of % respondents) used to obtain their fertilizer

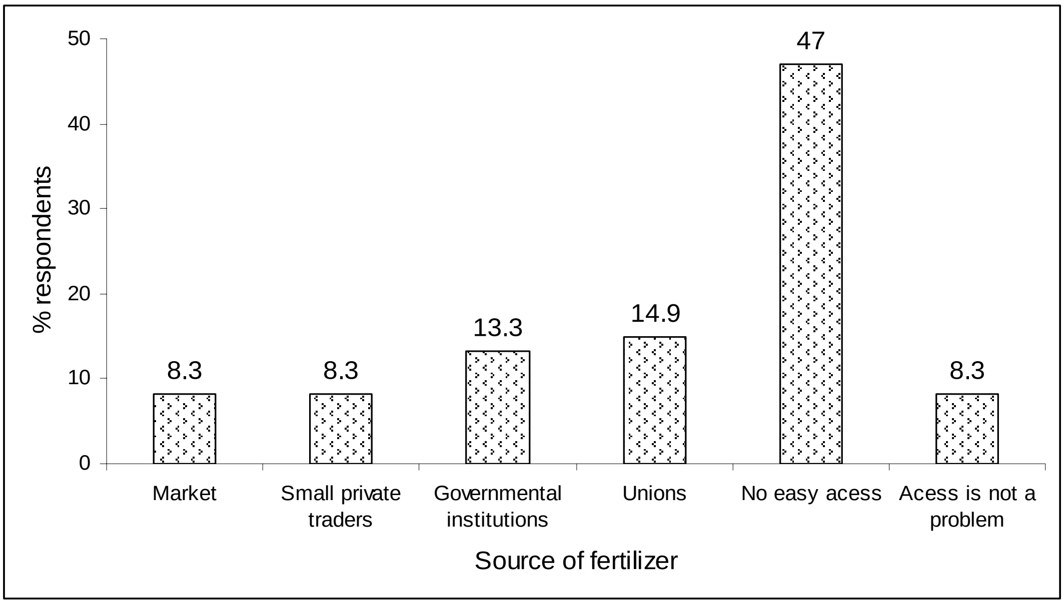

Figure 7. Sources of fertilizer described by farmers as easy access to inorganic fertilizer (N=183)

Farmers' evaluation of farmer's cooperatives service in supplying fertilizer

Highest percentage of respondent farmers (30.6%) evaluated the quality of service they are getting from farmers cooperatives as bad (Fig. 8). The percentage of farmers who rated the quality of service provided by farmer cooperatives as better and good were nearly equal with 23.1 and 24.2% respondents respectively. Those who responded not having cooperatives around them were 9.7%.

Figure 8. Farmers' evaluation of the service provided by farmer's cooperatives

DISCUSSION

Farmers reported different types of soils based on visible criteria, such as soil color and texture. Reddish brown soil is the most commonly identified type of soil in the study area. Farmers reported that the fertility of reddish brown soil is lower than that of black soil. Other farmers suggested that when the fertility of the soil is exhausted it changes its color from black to reddish brown. Most farmers reported that soil fertility and the amount of fertilizer used were declining in the last 1-5 decades. Along with those who do not totally apply fertilizer, the farmers, whose fertilizer use is declining might have been discouraged by the various constraints of fertilizer use, of which high cost and timely unavailability of fertilizer are the most important ones. To motivate these farmers use fertilizer at the recommended rate, farm gate price of fertilizer has to be reduced as suggested by Aklilu (1980). The use of user friendly soil fertility testing tools like that of reported by Ditzler and Tugel (2002) are very important for use by farmers and field workers, which facilitates frequent monitoring of the change in the fertility of the soil, and to make point recommendation of fertilizer than blanket recommendation, which is a common practice in most developing countries.

Some farmers, on the other hand, replied that the fertility of the soil in their farm is increasing. In a key informant discussion, these farmers justified that the fertility of the soil is dependent on the way the soil is handled and the soil fertility management practices used by farmers. The proportion of farmers, whose fertilizer use increased was relatively high. This increased use of fertilizer might have arose from the decline in the fertility of the soil over time, which might have in-turn reduced the response from applied fertilizer.

As acidity is the major problem of the soil in SSA countries and Western Ethiopia, which limits the availability of P, acid soil management practices, such as the application of lime is very important (Wortmann et al., 2003; Rao et al., 1993), which neutralizes the pH and increases the availability of applied P. Since, farmers rated soil erosion as the most important cause of low soil fertility, farmers need to be empowered to enhance the use of erosion controlling practices, such as contour ploughing, planting of vetiver grass and other grasses against the slope, and terracing, In addition, to reduce the acidifying effect and dependency of the soil to fertilizer, farmers need increase the use of other alternative soil fertility management practices, such as crop rotation, the use of compost, biological nitrogen fixation, and control of erosion. Thus, farmers should be encouraged and supported to use such alternative soil fertility management practices by training, research and development programs.

Low crop yield in good season, change in soil color and thickness, reduced growth and change in crop color, and shift in weed biomass were found to be the most important soil fertility decline indicators of farmers in the survey area. These results are in agreement with those of Elias (2002). Soil erosion followed by long term mono cropping was ranked as the most important causes of low soil fertility problem. Most farmers failed to obtain fertilizer at the right planting time. Some of the most important factors, which hindered the use of fertilizer at planting time, were high cost, timely unavailability, absence of credit, and unavailability of fertilizer in the required amount. The problem of lack of credit was exceptionally high at Assosa; hence, credit options should be made available to these farmers. The rest of the problems could be reduced by improving the fertilizer transportation, distribution systems and the efficiency of fertilizer supplying institutions, such as farmers' cooperatives.

Most farmers believed that long term use of inorganic fertilizer reduces the fertility of the soil. These results were in agreement with that of Elias (2002), in which farmers perceived that the soil gets addicted to fertilizer; consequently becoming weak and powerless. The soil acidifying effect of DAP (Smaling et al., 1992), and nitrogenous and sulfur fertilizers (Wortman et al., 2003) might have caused the decline in the fertility of the soil. DAP is the most commonly used fertilizer as compared to urea and other nitrogenous fertilizers, and thus, it is the main acidity causing inorganic fertilizer in most SSA countries. However, the problem of acidity caused by the application of inorganic fertilizers can be minimized by the application of lime, and the problem is not more critical than not using fertilizer.

To increase food production and to meet the growing food demand of developing countries, soil fertility management practices, mainly the use of inorganic fertilizers need to be given due attention. The use of inorganic fertilizer can be enhanced through various strategies, of which policy consideration, such as improving the rural transportation and distribution systems of fertilizer, creating conducive fertilizer marketing environment, improving the fertilizer taxation system, improving access to credit and credit returning system, improving the capacity of fertilizer supplying firms is the most important one.

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