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Endeshaw Abatenh
Institute of Biodiversity Conservation

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The Role of Traditional Practice of Cereal-Legume Cropping Systems in the Improvement of Soil Fertility by Enhancing Soil Microbes in Tigray, Ethiopia

Befekadu Teshome[*], Endeshaw Abatineh and Endegena Ayinalem

[*]Ethiopian Biodiversity Institute, Microbial Biodiversity Directorate, Ethiopia.

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ABSTRACT

Indigenous knowledge is, broadly speaking, the knowledge used by local people to make a living in a particular environment. This study aimed to study the traditional practice of cereal legume cropping system and document the indigenous traditional community knowledge of soil fertility improvement by farmers in Tigray region of Ethiopia. In addition, it attempted to assess the existing knowledge of farmers about the role of microbes in improving soil fertility during legume-cereal cropping. A total of 71 farmer-informants were selected using simple random sampling technique from the study area. A pre-tested and adjusted semi-structured interview questionnaire was designed and administered to explore farmers' soil classification techniques, farmers' indigenous and inherent techniques of soil fertility assessment, cropping systems and their knowhow about microbes associated with legume nodules and their effects in the improvement of soil fertility and growth of crops. Descriptive frequency statistics (Central tendency, dispersion and percentiles) was used to evaluate all the variables using SPSS (2011) software ver.20.

The three most common farming practices carried out by farmers in all study provinces (*woredas*) are; strip cropping (82% of respondents), crop rotation (79% of respondents), and mono-culture cropping (54% of respondents), respectively. The most common types of crops they combine during crop rotation are sorghum, teff, barley, maize and chick pea. Twenty eight percent of the respondents follow this combination of cereal and legume crops in their crop rotation farming system. This study also found out that most farmers living in the study area are aware of the role of legumes in soil improvement but they were not able to reason out how legume root nodules help the enhancement of soil fertility.

Keywords: Traditional knowledge, Microbes, Crop rotation, Tigray region, Ethiopia

INTRODUCTION

Indigenous knowledge (IK) is, broadly speaking, the knowledge used by local people to make a living in a particular environment [1]. It can be defined as "A body of knowledge built up by a group of people through generations of living in close contact with nature" [2]. The term "Indigenous knowledge" sometimes refers to the knowledge possessed by the original inhabitants of an area, while the term "local knowledge" is a broader term which refers to the knowledge of any people who have lived in an area for long period of time. As stated by Langill [3], such knowledge evolves in the local environment so that it is specifically adapted to the requirements of local people and conditions. It is also creative and experimental, constantly incorporating outside influences and inside innovations to meet new conditions. Langill [3] further advised that considering indigenous knowledge as "old fashioned", "backwards", "static" or "unchanging" is a big mistake. Thus, studying traditional indigenous knowledge of a community and documenting it is not a simple task of gathering former knowledge but it is an act of searching tremendous knowledge originated and developed for many generations in a particular population through social experimentation and creation.

Farmers in different parts of the world practiced different traditional cropping systems. Legume-cereal cropping is one of the most frequently employed farming systems. Legumes are potential sources of plant nutrients that complement/supplement inorganic fertilizers for cereal crops

Corresponding author: Befekadu Teshome, Ethiopian Biodiversity Institute, Microbial Biodiversity Directorate, Ethiopia, Tel: 251932151668; E-mail: Beftesh@gmail.com

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because of their ability to fix biological nitrogen (N) when included to the cropping systems. By fixing atmospheric N_2, legumes offer the most effective way of increasing the productivity of poor soils either in monoculture, intercropping, crop rotations or mixed cropping systems [4].

Crop rotation is a practice of rotating/changing the type of crops grown in the field each season or each year (or changing from crops to fallow). It is a key principle of conservation agriculture because it improves the soil structure and fertility, and because it helps control weeds, pests and diseases [5]. Farmers in ancient cultures as diverse as those of China, Greece, and Rome shared a common understanding about crop rotations. They learned from experience that growing the same crop year after year on the same piece of land resulted in low yields and that they could dramatically increase productivity on the land by cultivating a sequence of crops over several seasons. They came to understand how crop rotations, combined with such practices as cover crops and green manures, enhanced soil organic matter, fertility and tilth [6].

Intercropping is also an ancient practice, placed on the fringes of a ‘modern agriculture’ dominated by large areas of monocultured, resource-consuming and high-yielding crops. Intercropping is considered as a means to address some of the major problems associated with modern farming, including moderate yield, pest and pathogen accumulation, soil degradation and environmental deterioration, thereby helping to deliver sustainable and productive agriculture [6]. It involves two or more crop species or genotypes growing together and coexisting for a time. This latter criterion distinguishes intercropping from mixed monocropping and rotation cropping. Intercropping is common, particularly in countries with high amounts of subsistence agriculture and low amounts of agricultural mechanization [5].

Developing countries such as Ethiopia, Niger, Mali China, India, and Indonesia have shown considerable interest in intercropping to enhance productivity [7]. In particular, cereal/legume intercropping is commonly employed in China and sub-Saharan Africa and has shown over-yielding and nutrient acquisition advantages under adverse conditions. Furthermore, intercropping also provides an important pathway to reduce soil erosion, fix atmospheric N_2, lower the risk of crop failure or disease and increase land use efficiency [7].

Intercropping is often undertaken by farmers practicing low-input (high labor), low-yield farming on small parcels of land. Under these circumstances, intercropping can support increased aggregate yields per unit input, insure against crop failure and market fluctuations, meet food preference and/or cultural demands, protect and improve soil quality, and increase income. Intercrops can be divided into mixed intercropping (simultaneously growing two or more crops with no, or a limited, distinct arrangement), relay intercropping (planting a second crop before the first crop is mature), and strip intercropping (growing two or more crops simultaneously in strips, allowing crop interactions and independent cultivation) [5].

Various types of intercropping were known and presumably employed in ancient Greece about 300 B.C. Theophrastus, among the greatest early Greek philosophers and natural scientists, notes that wheat, barley, millets and certain pulses could be planted at various times during the growing season often integrated with vines and olives, indicating knowledge of the use of intercropping [8]. Traditional agriculture, as practiced through the centuries all around the world, has always included different forms of intercropping. In fact, many crops have been grown in association with one another for hundred years and crop mixtures probably represent some of the first farming systems practiced [9]. Now a day, intercropping is commonly used in many temperate, tropical and subtropical parts of the world particularly by small-scale traditional farmers [10]. Traditional multiple cropping systems are estimated to still provide as much as 16-22% of the world’s food supply [11].

In Ethiopia, plow agriculture in its current form as a dominant tool appears in rock painting dating as far back as 500 AD. This annual crops (grain, legume and oil seed) based plow agriculture was centered in the central and northern highlands of Ethiopia. Tigray is located in the Northern major highlands of Ethiopia. Even though it is difficult to find complete and exact information when and where crop rotation, intercropping and other traditional cropping systems were started in Ethiopia, it is understood that the practice of cropping began many centuries ago. By fixing atmospheric N_2, legumes offer the most effective way of increasing the productivity of poor soils either in monoculture, intercropping, crop rotations or mixed cropping systems. These cropping systems are commonly used in many temperate, tropical and subtropical parts of the world particularly by small-scale traditional farmers. This study aimed to study the traditional practice of cereal legume cropping system and document the indigenous traditional community knowledge of farmers in Tigray region of Ethiopia. In addition, it attempted to assess the existing knowledge of farmers about the role of microbes in traditional cropping systems, especially in legume-cereal cropping, in a systematic way.

MATERIALS AND METHODS

Description of study area

Survey study was carried out in two major sorghum producing zones of Tigray region in Ethiopia. The sample collection site is shown in **Figure 1**. It comprises Central Tigray and South Tigray zones which are found in the northern part of Ethiopia. Based on the GPS data recorded during sample collection, the sample collection sites are located between 12°28.0988’-13°19.9522’N and

38°53.1815’-39°40.9870’E with an altitude range of 1342-1822 m a.s.l.

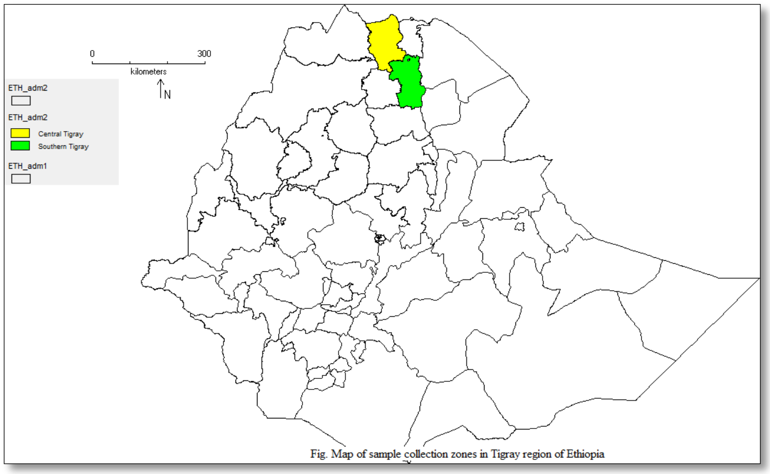

Figure 1. Study zones in Tigray region of Ethiopia.

Data collection

Data collection was undertaken in 8 administrative units (kebeles) of 3 *woredas* in Tigray region of Ethiopia, which were considered to be representative of the practice of cereal-legume cropping system in the highland areas of Ethiopia. A semi-structured interview based survey was used to collect the data [12,13]. In each kebeles, the research team randomly selected a representative group of farmers with different ages and social classes. The team used interview guides from the study *woreda* agricultural office during individual and group discussions so that the team members easily understand farmers’ perceptions of soil fertility, techniques of soil classification, and their cropping systems. They also attempted to assess farmers’ knowledge/knowhow of microbes associated with legumes and their effects in soil fertility improvement [12,13].

Seventy one farmer-informants were selected using simple random sampling technique from the study area. Semi-structured interview questionnaire was designed and administered to explore farmers’ soil classification techniques, farmers’ indigenous and inherent techniques of soil fertility assessment, cropping systems and their knowhow about microbes associated with legume nodules and their effects in the improvement of soil fertility and growth of crops. The semi-structured interview questionnaire was pre-tested and adjusted before its full administration [12]. The questionnaire was administered by researchers working in Ethiopian Biodiversity Institute, microbial biodiversity directorate; bacteria and fungus case team and agricultural experts working at the study areas. Focus group discussion was made with members composed of representatives of each kebele who were community elders and young farmers who have been engaged in farming. 8-12 informants in each focus group were included for the study [12].

Data analysis

Descriptive frequency statistics (Central tendency, dispersion and percentiles) was used to evaluate all the variables using SPSS (2011) software ver.20. ANOVA was done to compare the mean values of the variables. P-value less than 0.5 were taken as significance.

RESULTS AND DISCUSSION

A total of 71 informants were included in this study from 8 kebeles (smallest administrative unit) of the 3 *woredas* (big administrative area comprising 25 kebeles on average) in the study zones of Tigray **(Table 1)**.

Table 1. Frequency and percent description of informants in each *woreda*.

***Woreda* name**	**Frequency**	**Percent**
Tanqua Abergelle	33	46.5
Raya Azebo	28	39.4
Raya Alamata	10	14.1
Total	71	100.0

An average of 24 farmer informants with mean age of 44 was included in each *woreda*. The largest number of informants was 33 and the least was 10 in Tanqua Abergelle *woreda* and Raya Alamata woreda, respectively **(Table 1)**.

There were 8 focus discussion groups in the 8 *kebeles* of the 3 *woredas*. The frequency distribution of each discussion group with informants by *kebele* is shown in **Figure 1**.

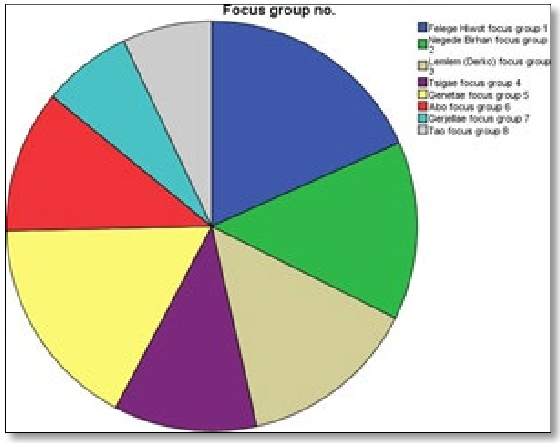

Figure 1. Focus group percentage distribution.

Characteristics of respondents/informants

Farmer informants who were included in the study were from different age group, education level and livelihood background. The mean age of the informants was 48 and their mean family size was 6. Their education level was also different. 49% of the respondents were illiterates but 51% of them completed either primary and/or secondary school **(Figure 2)**. Ninety three percent of the total informants lead their life by engaging in mixed agriculture and the rest 3% rely only on crop cultivation **(Figure 3)**.

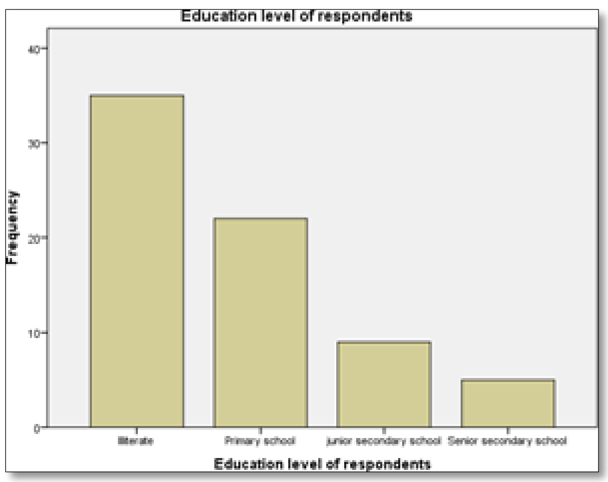

Figure 2. Education level of respondents.

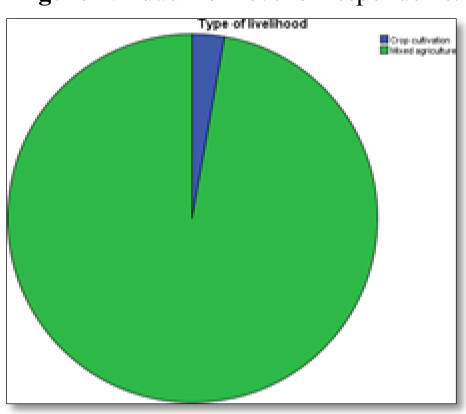

Figure 3. Livelihood of respondents.

Farmers' techniques of soil classification

This study indicates that farmers living in the two zones of Tigray have various techniques of traditional practices adopted for classification of soil. All of the respondents answered that they basically use soil color, soil texture and gravel content of the soil as criteria to classify soil. Different types of soil color are used by farmers in all *kebeles* of the study areas. The major soil color types used by farmers are black, brown, red and gray. In addition, three major types of soil texture; rough, smooth and muddy are most often used by all farmers in the study area. They adopt different methods to assess the soil texture. Observation by eye, hand touch and ploughing are the most important methods frequently adopted by farmers to differentiate the soil roughness or smoothness.

Farmers' techniques of soil fertility assessment

Farmers in the study area do have tremendous indigenous and inherent techniques of soil fertility assessment. Even though they traditionally adopt various techniques of soil assessment, they most frequently use soil color and texture change, productivity decline, appearance of sand in the field, poor seedling germination immediately after sawing, yellowing and other coloration of crop leaves during crop growth, dicotyledonous weeds occurrence and soil fauna (earth worm casting activity), soil workability, slope and the soil's depth criteria. Sixty eight percent of the respondents explained that they use these criteria in combination in their day to day activity of farming. Fourteen percent of the respondents use this criterion in combination except soil fauna (Earth worm casting activity), appearance of sand in the field and poor seedling germination immediately after sawing to assess the soil fertility.

Forty two percent of the respondents explained that they consider the soil is fertile if the soil has black color, smooth texture and has high water holding capacity. But, fourteen percent of the respondents said that they take the soil fertile if it is also red in color but smooth in texture. In general terms, farmers give soil rank as fertile if it has black color, red color, gray color and brown color, respectively.

Farmer respondents explained that they use dicotyledonous weeds occurrence as a means to tell whether the soil is either fertile or infertile. It is found that 15 types of dicotyledonous weeds are used by farmers as indicators of fertile soil. They also mentioned another 9 types of dicotyledonous weeds that are used by them as indicators of infertile soil. The most commonly used fertile soil indicator weed is gemale (39.44% of respondents) which is followed by weed mestenagir (36.62% of respondents) and hitsihitsi (28.13% of respondents). On the other hand, akenichira (100% of respondents) is the most frequently employed infertile soil indicator weed followed by kinche (53.5% of respondents) and eshoh mergem (28.2% of respondents).

Farmers' methods of cropping systems and their knowledge about the role of microbes associated with legume root nodule

This study showed that farmers in Tigray district practice different types of cropping systems. They perform one or the other cropping system at different time; Mono-cropping, crop rotation, intercropping, sequential cropping, and strip cropping. The three most common farming practices carried out by farmers in all study *woredas* are; strip cropping (82% of respondents), crop rotation (79% of respondents) and mono-culture cropping (54% of respondents), respectively.

The main reason farmers responded why they rotate crops from seasons to seasons is to increase yield, improve soil fertility and control weeds, pests and diseases. Around 82% of the respondents practiced crop rotation in every other year. The rest respondents practiced crop rotation in less than year time. The most common types of crops they combine during crop rotation are sorghum, teff, barley, maize and chick pea. Twenty eight percent of the respondents follow this combination of cereal and legume crops in their crop rotation farming system. A sorghum, teff and sesame seed is the next common combination of crops followed by farmers during crop rotation time.

Farmers consider different factors in selecting the right crops to combine them for crop rotation system. The major criteria they follow are ability of the combined crops in complementing one another (44%), ability of the crop in improving the soil fertility (42%) and ability of the crops in covering the soil (39%), respectively. Only 17% of the respondents included in the study accounted the type of roots the crops have is used in selecting the right crops to combine in crop rotation practices. Forty four percent of farmers living in the study district also have frequent practice of using fallow land for crop rotation rather than combining crops. They take five years on average of duration of fallow land period between two consecutive crop rotations.

All of the farmer respondents are aware of the difference between the root types of cereal and legume crops. Eighty six percent of the farmers do not have the knowhow about the association among the roots, root nodules and N_2 fixation carried out by microbes associated with legume roots. But, in the contrary to this fact 89% of the respondents are found to have the knowledge about the importance or the role of legume crops during crop rotation in the improvement/enhancement of soil fertility. This indicates that most farmers living in the study area are aware of the role of legumes in soil improvement but they do not have the scientific background about the role of microbes associated with legume root nodules in the enhancement of soil fertility [14,15].

CONCLUSION

The three most common farming practices carried out by farmers in all study provinces (*woredas*) are; strip cropping

(82% of respondents), crop rotation (79% of respondents), and mono-culture cropping (54% of respondents), respectively. The most common types of crops they combine during crop rotation are sorghum, teff, barley, maize and chick pea. Forty five percent of farmer respondents living in the study district also have the practice of using fallow land for crop rotation rather than combining crops. They take five years on average of duration of fallow land period between two consecutive crop rotations.

This study further more indicated that farmers in the study area do have tremendous indigenous and inherent techniques of soil fertility assessment. Even though most of them are aware of the role of legumes in soil improvement, they do not have the scientific background about the role of microbes associated with legume root nodules in the enhancement of soil fertility as indicated in other study done by the same authors of this study in North Shoa of Ethiopia.

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