

Farmers Traditional Knowledge on Teff (*Eragrostis tef*) Farming Practice and Crop Rotation in PGP Microbes Enhancement for Soil Fertility in West and East Gojam

Birhanu Gizaw Tegene^{*}, Zerihun Tsegay, Genene Tefera, Endegen Aynalem, Misganaw Wassie

Ethiopian Biodiversity Institute (EBI), Addis Ababa, Ethiopia

Email address:

gbirhanu@ibc.gov.et (B. G. Tegene)

^{*}Corresponding author

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Abstract: Teff (*Eragrostis tef*), a cereal grain included in grass family of Poaceae, diversified and endemic to Ethiopia supports more than 70-75% of Ethiopia's population as staple and co-staple food. Teff farming and processing for food is based on traditional indigenous knowledge of farmers vary in different teff growing areas. The objective of this study was to assess and document traditional knowledge of farmer's crop rotation and soil fertility improvement for teff farming and utilization practice in east Gojam and West Gojam. Data was collected using structured, semi-structured questionnaire, personal interview, focus group discussion and key informant interview. Then a structured and semi-structured questionnaire was designed to collect information across 20 group informants (100 listed elder informants) who involved in the study from seven districts. The major Teff farming steps, selection teff variety, preparation of farming area, lost teff variety, the role of crop rotation in teff productivity, type of crop used for rotations in soil fertility, role of microbes in soil fertility through crop rotation, the traditional farming equipment, traditional storage and pile making were described. Among the respondents 75% of those in the study area were male and 25% female and almost all study participants were evolved from Amhara ethnic groups that involved in teff farming. Teff variety which were dominant and locally called and recognized by many farmers in East and west Gojam were, Magna, Dabo, Sergegna, Nech Bunign, Godashigne, kuncho, Amerach, Qeytala, Cross 37, Azene, Qomten, Lemma, Nech laba, Avola Bunign, Bose, Yilmana, Etsub, Mure, kora. 100% of respondent used crop rotation for teff farming and productivity. 92% of respondent of east Gojam mostly used, vetch (*Lathyrus sativus*)^{*} niger, (*Guizotia abyssinica*) and 81% of respondent of west Gojam in addition to vetch (*Lathyrus sativus*)^{*} niger, (*Guizotia abyssinica*) also used chick pea (*Cicer arietinum*), Barely (*Hordeum vulgare*) Bean (*Phaseolus vulgaris*), Pea (*Pisum sativum*), chickpea (*Cicer arietinum*), maize used for crop rotation in teff farm land, 32% respondent also used rotation of different teff cultivar annually to improve their soil fertility and teff productivity. This traditional knowledge in using of legume plant for crop rotation in teff yield and productivity tells us that farmers indirectly keep the balance of soil microbial community especially that plant growth promoting Microbs (PGPR/F) involved in Nitrogen fixation, phosphate solubilization, and Phytohormone production, siderophore production and Antibiotics production.

Keywords: Crop Rotation, Chick Pea, Microbs, Pea, Teff, PGPR, Vetch

1. Introduction

According to Nicolai Vavilov, teff originated and was domesticated in Ethiopia between 4000 – 1000 BC [33]. Teff (*Eragrostis tef*), a cereal grain that is included grass family of Poaceae, and endemic and diversified to Ethiopia and it has

been widely produced for many centuries [37]. Within the genus *Eragrostis* 43% of the species seem to have originated in Africa, 18% in South America, 12% in Asia, 10% in Australia, 9% in Central America, 6% in North America and

2% in Europe [8]. Of the 54 *Eragrostis* species listed in Ethiopia, 14 (or 26%) are endemic [11]. *Teff Eragrostis tef* (Zucc.) Trotter is a self-pollinated, annual, warm season grass that is used throughout the world as grain for human consumption and as forage for livestock. It is a five stem, leafy grass with a shallow root system. Teff grain is found widely in most part of the country mainly grown under diverse agro-ecological conditions in the altitude ranging from 1800 to 2100 meters above sea level. The major Teff producing areas are Amhara, Oromia, Tigray and South nation and nationality regional people of Ethiopia. In Ethiopia there are several varieties of teff, each unique to specific growing condition [25]. 34 named Ethiopian teff cultivars based on morphological characteristics was published in 1975 [15]. [33] describes three main types of teff grain, white, brown and mixed (brown and white), Teff grass and summer annual grass it is reported to be drought tolerant and grow on a wide variety of soils which is not surprising considering that there are nearly 4000 varieties identified worldwide [13]. It is adapted and distributed in a wide range of environment even in marginal soils [23]. Teff based farming system is an indigenous and sustainable agricultural system in Ethiopia [37]. About 2,730,272.95 hectares of land is assumed to be covered by teff in the country [10]. East Gojjam is the leading zone in Teff production constituting more than 10 percent of the national annual Teff production. There are also potential Teff producing zones in Amhara (North Gondar, North Shewa and West Gojjam zones) [16]. Teff supports more than 60-75% of Ethiopia's population as staple food and believed as a traditional medicine especially for diabetic people in many areas of the country. Teff is also quite high in energy, and has an average fat content of about 2.6%. Protein content also tends to be just as high as, or higher than, that of other cereals, ranging from 8% to 15% (with an average of 11%). While the vitamin content is about average compared to other cereals, the fermentation process of making injera generates additional vitamins, further enhancing the value of the grain. In addition, the mineral content shows especially good values for iron and calcium. Teff does not contain gluten and is therefore a promising alternative for those suffering from coeliac disease or other forms of low gluten tolerance. Teff is highly nutritious and is an important part of Ethiopia's cultural heritage and national identity. Being labeled as one of the latest super foods of the 21st century, like the ancient Andean grain quinoa, teff's international popularity is rapidly growing [9]. Teff is a very important crop in Ethiopia, both in terms of production and consumption. In a country of nearly 90 million people, approximately 6 million households grow teff [3]. Ethiopian farmers grow this crop for a number of merits, which is mainly attributed to the socioeconomic, cultural and agronomic benefits. Indigenous knowledge is a store of experience and awareness of native society on technologies, practices and beliefs that forms the basis for production of different crops [26, 39]. Farmers have a wealth of indigenous knowledge on the production of teff crops in their communities that could be useful for a robust crop

breeding program. Although teff became high value and socially important crop for Ethiopian culture, information on local indigenous knowledge on crop rotation and soil fertility increment on production and yield improvement as well as management and cultivar selection criteria of farmers is insufficient or not documented properly, and, hence, the attributes are known by the scientific community. Such knowledge needs to be fully explored and documented for use by researchers. Thus, detailed analysis of farmers' indigenous knowledge on production and management system with their selection criteria has tremendous contribution for cultivar development; improved management practices and develops teff genetic resources conservation strategies, as well as bio fertilizer development for present and future generation. This study was therefore designed to search valid and reliable information for assessing and documenting Farmers traditional Knowledge on Teff (*Eragrostis tef*) Farming practice and the role of Crop Rotation in plant growth promoting Microbes enhancement for soil fertility in West and East Gojam.

2. Materials and Methods

2.1. The Study Area Description

The study was conducted in 7 selected districts from West Gojam zone, East Gojam Zone, Amhara regional state. East Gojam Zone is bordered on the south by the Oromia Region, on the west by west Gojjam, on the north by south Gondar, and on the east by south Wollo; the bend of the Abay River defines the Zone's northern, eastern and southern boundaries. 10°31'44.7"N & 37°51'10.2"E. West Gojjam (Mirab Gojjam) is a Zone in the Amhara Region of Ethiopia. West Gojjam is bordered by North Gondar, on the north by Lake Tana, and the Abay River which separates it from the South Gondar, and on the east by east Gojjam. Coordinates: Latitude: 10.97379 North, Longitude: 37.46814 East. Gojam at Average altitude, 1788m.a.s.l.

2.2. Selection of Participating Households

Selection of individual household was made on meeting with district agricultural experts and key informants familiar about the Teff crop. One hundred teff producing households were selected from the from 7 districts and 14 kebele of West Gojam, East Gojam. The study Kebeles (the smallest administrative unit in Ethiopia) were selected purposively based on their distribution, production potential of Teff and Teff Variety. Elders (whose age is 20 and above) were purposively used with different socioeconomic back grounds in the study and their names and ages were listed with the help of kebele leaders and local guiders.

2.3. Data Collection

In order to document and assess the indigenous knowledge on the role of crop rotation in Teff farming and utilization practice both Primary and secondary data were collected. Then a structured and semi-structured

questionnaire was designed to collect information across the 100 listed elder informants. Both interviews in the village and of questionnaires were filled. Secondary source of data was obtained from the agricultural office of the district, from different books, journal and research article. The questionnaires mainly focused on informants Socio demographic characteristics and experience on their traditional knowledge of Teff productions and farming practice, role of crop rotation in soil fertility improvement, role of microbes in crop rotation, types of crop during rotation, equipment used for Teff farming, Teff variety and seed selection criteria, Teff conservation practice for local variety, the role of alternative cropping and mixed cropping, in teff productivity, the role of microorganism about teff productivity, The role of gender perception in Teff farming and management. Accordingly, about 10% (100) of elderly traditional resourceful inhabitants (75 males & 25 females) of the kebele/village were identified and interviewed to solicit their local knowledge on Teff farming and utilization practice. The sample size was determined by following [12] procedure, and then a simple random sampling was used to select and interview the target 100 adult individuals.

2.4. Sampling Procedures

Within Ethiopia, the regions of Gojam and Shewa (located in the central highlands), Gonder, Wello and Welega are the major teff production areas [24]. Based on the annual grain report of 2005/2006 E. C cropping season made by East and west Gojam Zone Agriculture and Rural Development Bureau (NSAZRDB), among the 24 districts with in the administrative zone east and west Gojam has reported to be the leading district on Teff grain production covering about 1,565.3 hectares of land. East Gojam district is divided in to 14 rural districts with a total household number of 213,568 and West Gojam-zone 184,703 [5]. For the purpose of this study multi stage sampling technique was employed to select sample farmers from probability sampling method. A proportional allocation formula was employed to select respondents from each sample kebeles and each farmer's category. Table. 1

$$n = \frac{N}{1 + N(e)^2}$$

Where: Ni- The total household heads in each *Kebele*

N- The total household heads in the sample *Kebele*

n- Sample size of households in the study area.

Table 1. Sampled household per districts.

	Gojam District	Kebele	West Gojam (HH) 2,106,596	East Gojam (HH)2,153,937	Sample household
1	Degen yetnora	Yetnora			15
2	Bichena/Enemay	Gotera			19
3	Enarj Enawga	Zechena			6
4	Huleeju Nesae	AddisZemen			20
		DebreGubae			5
5	BahirDar zuria	Yinsae 3			8
6	Mecha	Batima			13
7	Debecha	Arbuk			14
	Total sampled HH				100

2.5. Key Informant Interview

Purposively the researcher selected 12 respondents who can be able to provide detail information regarding on the farmers traditional Knowledge on teff farming practice and utilization in the study area. These include 7 crop development and farmers training center (FTC) leaders from district agriculture and rural development bureau and five village leaders (Figure 1)



Figure 1. Key informant interview.

2.6. Statistical Analysis

The data analysis involved various descriptive statistics such as means and percentages. For each questionnaire, the percentage of farmers who gave similar response was

calculated. The summarized variables include, household size, age structure, land holding size. STATA ver13 was used for data analysis.

3. Result and Discussion

3.1. Socio-Economic Characteristics of the Selected Households (Socio Demographic Data)

The study covered 20group informants having 100 adult individuals in 7 districts Amhara Regional state in West Gojam & east Gojam particularly Degen, Enemay, Enarj Enawga, Huletiju Nesae, BahirDar zuria, Mecha, Denbecha. From all study participants 25% were females and 75% were males making the female to male one to three ratio. The higher proportion of males gender may possibly be due to the fact that most of the farmers interviewed were married (98%), compared to the divorced and widow (1%) categories. The age groups of interviewed farmers in this study were different age ranges; 0-20 years (6%), followed by 21 - 30 years (28%), 31-40 years (31%) and 41-50years (24%), 51-60 years (9%) and above 61 years old (2%) (Table 1). In general 65% of the population involved in the

study was the age in between 0-40years old, while the rest of 35% were the ages greater than 40-60 years old. 89% of the study participants were from rural area and the rest 11% from urban. With regard to ethnic group majority of study participants (100%) are Ahmara. With regards to educational backgrounds 35% of the respondents were completed primary school, 8% of the respondents were completed secondary school, and 57% of the respondents were illiterate. In relation to family size 35% of the respondent has 0-3 family numbers, 50% of the respondent has 4 to 6 family numbers, 12% of the respondent has 7-9 family numbers and 3% of the respondent has above 10 family numbers. With regards with Income source of farmers, 19% depend only Teff farming, 77% depend on both Teff farming and animal rearing, 3% their income depend on renting their farmland and trade. In terms of their Teff farm size 36% farmers have less than one hectare farm land, 26% farmer has one hectare, and 38% more than one hectare farmland (Table 2).

Table 2. Socio demographic Data.

	Item	Dejen yetnora	Bichena kebele	Gotera Gemna kebel	Debrework Deja nesae	B/D Yenesae 3 kebele	Mecha Bachima kebele	Denbecha	SUM	%
Sex	Male	14	2	1	25	8	13	12	75	75%
	Female	1	17	5	0	0	0	2	25	25%
	total	15	19	6	25	8	13	14	100	100%
	0-20	0	3	0	0	1	1	1	6	6%
Age	21-30	5	6	1	6	4	2	4	28	28%
	31-40	3	4	4	11	1	2	6	31	31%
	41-50	6	2	0	6	2	5	3	24	24%
	51-60	1	2	1	2	0	3	0	9	9%
	>61	0	2	0	0	0	0	0	2	2%
	Total	15	19	6	25	8	13	14		
	urban	3	0	0	0	8	0	0	11	11%
	rural	12	19	6	25	0	13	14	89	89%
Ethnicity	Amhara	15	19	6	25	8	13	14	100	100%
	Other	0	0	0	0	0	0	0	0	0
	Total	15	19	6	25	8	13	14	100	100
Education	Illtrate	5	11	5	12	7	12	5	57	57%
	1-6	5	2	0	13	1	1	8	30	30%
	7-8	3	0	1	0	0	0	1	5	5%
	9-12	2	6	0	0	0	0	0	8	8%
	College	0	0	0	0	0	0	0	0	0
	Unv	0	0	0	0	0	0	0	0	0
	Total	15	19	6	25	8	13	14	100	100%
	0-3	7	10	3	8	1	2	4	35	35%
	4-6	7	7	3	15	7	5	6	50	50%
Family size	7-9	1	2	0	2	0	4	3	12	12%
	10-12	0	0	0	0	0	2	1	3	3%
	>12	0	0	0	0	0	0	0	0	0
	Total	15	19	6	25	8	13	14	100	100
TeffFarm/ Hektar	<1	4	9	2	8	5	4	4	36	36%
	>1	8	5	2	8	2	6	7	38	38%
	1	3	5	2	9	1	3	2	26	26%
	Farm	2	3	0	2	2	8	2	19	19%
Income source	Ani. Roaring	0	0	0	0	0	0	1	1	1%
	Both farm+animal Roaring	11	16	6	24	6	5	9	77	77%
	other	2	1	0		1	0	2	3	3%
Total		15	19	6						

3.2. Gender Role in Teff Farming Practice and Management

In seven districts, men are the main responsible for tasks

of land preparation, repeated ploughing upto, 5-7 times, planting in teff cultivation and teff cutting (Acheda) and raw seeding, while female farmers are responsible cleaning fields locally known as gulgualo, weeding and sowing seed in row,

Women have large role 65.0% in teff seed selection and sorting before sowing like selection for culinary use and maintenance of planting materials [1]. Teff seed cleaning is carried out at different stages, right after threshing of the crop (men tasks) and at a later stage just before planting using home made tools (sefed and wonfit) women's task. Winnowing at threshing time is done by men, a two-stage process, first threshed tef grain is separated from the rough straw and secondly, grain is further purified by wind from fine straw, inert materials, shriveled or broken seeds using wooden tools (layda). Men are responsible for this works.

3.3. Farmer's Awareness About Local Teff Variety and the Lost Variety from Thier Farm Land

In Ethiopia there are several varieties of teff, each unique to specific growing condition [24]. 34 named Ethiopian teff cultivars based on morphological characteristics was published in 1975 [15]. 95% of respondent in all districts do have awareness about local Teff variety, However Respondent from seven districts and Keble in the study area were asked about the lost teff Variety from their farmland because of improved variety released from agricultural research centers and over dominates, climatic change, soil retardation and deformity, and other market need, and several reasons. About 15 teff varieties were lost in the study area in the course of time mentioned by respondents. The same variety may have different names in different areas and languages and also different varieties by the same name, also showed that duplication of names were related to different utilization purposes of variety and the changing of vernacular names after exchange of variety between communities. However, the variety were one of the dominant variety of Teff that all respondent requested 100% frequently used for its high productivity yield for food, medicinal value, diseases and drought resistance (Table 3).

Table 3. Lost teff Variety in the study districts.

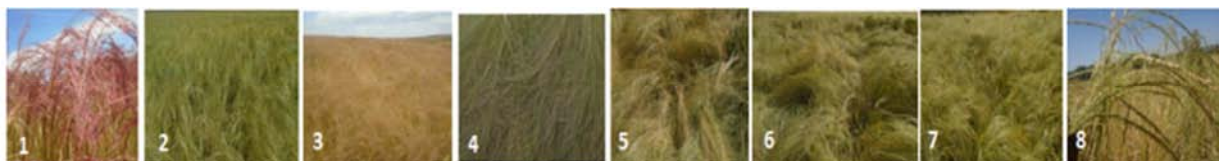
Districts	Lost Teff Variety from Farm Land
1 Degen Yet Nora Kebele)	Mekone, Emblabish, Mure, Chigar fenkil
2 Bichena (Getera kebele)	Nech jijae, Jimil engido, Biten engido, Chigar fenkil, Mure
3 Enarje Enawga (Deja Gemna kebele)	Jible, jijae
4 Hulet eij nese (DebreGubae &Addiszemen Kebele)	Busye
5 BahirDarZuria (Yenesae 3 kebele)	Sayentae, Murae, Gudo, Nech laba, Ansharo
6 Mecha (Bachima Kebele)	Gudo, murae
7 Denbecha (Zeleva &Sensel Gebriel Kebele)	Lemach, jinjir

3.4. Currently Cultivated Teff Variety in the Study Area

In Ethiopia there are several varieties of teff, each unique to specific growing condition [24]. 34 named Ethiopian teff cultivars based on morphological characteristics was published in 1975 [15]. Teff grass and summer annual grass. It is reported to be drought tolerant and grow on a wide variety of soils which is not surprising considering that there are nearly 4000 varieties identified worldwide [13]. In the study area fifteen varieties are currently cultivated in West and east Gojam. Figure. 2. The same variety may have different names in different areas and languages and also different varieties by the same name, also showed that duplication of names was related to different utilization purposes of variety and the changing of vernacular names after exchange of variety between communities. However, the variety were one of the dominant variety of Teff that all respondent requested 100% frequently used for its high productivity yield for food, medicinal value, diseases and drought resistance (Table 2.) According to [16]. Most of the Ethiopian farmers use traditional varieties of Teff and these are distributed all over the country. Local varieties such as GeaLamie, Dabi, ShewaGimira, Beten and Bunign, which are early maturing (<85 days), are widely used in areas that have a short growing period due to low moisture stress or low temperature. The same varieties are also used in areas with adequate rainfall and where double cropping is practiced. In the highly productive and major Teff producing regions of Gojam and Shewa, and in other regions where environmental stress is not severe, the local varieties such as Alba, Ada and Enatit are used.

Table 4. Currently Cultivated Teff In the Study Area.

Districts and Kebele in east and west Gojam	Currently Cultivated Teff In the Study Area
1 Degen Yet Nora Kebele)	Magna, Dabo, Kuncho, Sergegna, Nech Bunign, Berenti
2 Bichena (Getera kebele)	Magna/adal, Godashigne, kuncho, Bunigne, Gord, Dabo bunigne, Enat bunign
3 Enarje Enawga (Deja Gemna kebele)	Gorad, Qeytala, Amerach, Bunign, Quncho
4 Hulet eij nese (debreGubae &Addiszemen Kebele)	Qyelaba, Damenima, Nechdalga, Dabo, Quncho, Minjar, Bost, Avola, Yilmana, Bost, Etsub
5 BahirDarZuria (Yenesae 3 kebele)	Quncho, Dabo, Cross 37
6 Mecha (Bachima Kebele)	Azene, Quncho, Cross37, Dabo nech laba
7 Denbecha (Zeleva &Sensel Gebriel Kebele)	Murao, Dabo, Lameche, Qomten,



1. kora, 2. Magna, 3. Avola, 4. Bunign, 5. Boset, 6. Yilmana, 7. Etsub, 8. Mure

Figure 2. Some of cultivated teff crop variety.

3.5. Traditional Equipment for Teff Farming, Collection and Storing

Farmers in the study area used different traditional equipment for teff farming for ploughing, teff collection and temporarily storing where produced locally from wood, bamboo, iron. These locally called equipment's are Mofer, Manqya, Kenber, Eirf, Mensh, Lamed, Maragebya, Quna, Direb, Aqumada, Meberberya, Machid (Sickel) and

matarebya, gotera (Figure 3) In Gojam, traditional methods of threshing grains of teff (separating the grain head from the straw and separating the kernel from the head) animals walking on it. The process is arduous, time intensive (Figure 4). The traditional storage structure are sacks, teff straw reinforced mud made oval shape locally called Gottera. Teff grain is less storage pest problem compared to other crop (Figure 3).



Figure 3. Traditional equipment for teff farming

1. Mofer, 2. Maresha, 3. Miran 4. Wogel, 5. Kenber, 6. Erif, 7. Mensh, 8. Lyda (Lamed), 9. Matarebya 10. Megolgoya 11. Meserseria. 12. Metregya made from grass 13. Metrgya made from stick 14. Complet set of equipment during sorting teff grain 15. Sickel 16. MediumGotera 17. Large size Gotera 18. Kuna/Dirb 19. Complet set of Maresha 20. plough system



Figure 4. Teff collection, piling and teff grain sorting process.

3.6. Utilization of Teff

Farmers in East & West Gojam Zone used teff varieties for different purposes. 100% of respondent produced flour from all teff variety for injera preparation, Teff grain is ground into flour and fermented dough baked to make injera (a spongy, sourdough flatbread or A soft, porous, thin pancake) which is traditionally consumed with various meats and pulse sauces called wot,) [35]. According to [38, 40] Teff in Ethiopia is the preferred grain for making injera, primarily for its better sensory attributes (for example, taste, color, smell) and shelf

life. Besides, the ability to easily roll (softness) injera is an important quality attribute since this allows easy wrapping of the sauces (wot) consumed with it. From the discussion made, 95% farmers pointed out that Daboo teff variety was used as preparing Figuer 1 (Atmit), Anebabero, Engocha, Mekleft and Magna, Dalga and Dabo teff variety used traditionally for Porrage (Genfo) and Qita (unleavened bread) preparation. Other traditional preparations from teff flour include local alcoholic beverages called tela and katikala. Teff straw is used as animal feed, to plaster mud huts and to

make local grain storage silos called goteras [24]. Figure 5. 6. 7 & (Table 5). Farmers also traditionally used Daboo teff variety to make Atimite as medicinal usage especially for female give birth and for fractures bone [24]. suggested that Teff is processed into different foods and beverages including porridge, kitta (unleavened bread), gruel (atmit), a pancake-like bread called injera, and local alcoholic beverages such as opaque beer called tela, a spirit called arake and shamit at household level. According to [28] Farmers in East Gojam Zone used teff varieties for different purposes. They produced flour from Sergenga (56% and 38%), Magna (38% and 30%) and Daboo (50% and 76%) they used for all purposes (sale, kitta, anebabero, porrage with other cereals, injera with other cereals and for seed). [13] Also suggest so, the majority of farmers' used Magna and Sergenga teff for sale but Daboo tef seed for any type of home consumption.

Furthermore, teff flour is primarily used to make a fermented, sour-dough, flat spongy bread locally called Injera. Tef it is also eaten as porridge and also used as an ingredient of home-brewed alcoholic drinks.

Table 5. Use of Teff.

Utilization of teff for food	Teff Variety
1 Injera	All teff variety
2 Qita (unleavened bread)	All teff variety
3 Porrage	Daboo teff variety, Dalga, magna
4 Mekleft (Anebabero) for church ceremony	Daboo teff variety
5 Guberae (Anebabero) for Home Consumption	Daboo teff variety
6 Engocha	Daboo teff variety
7 Atmit (gruel),	Daboo teff variety
8 Alcoholic drink (Tella)	All teff variety
9 Sprite (Areke)	All teff variety



Figure 5. Injera with wot and the usual dish.



Figure 6. Anebabero and teff food product.



Figure 7. People using Local beer (Tella) as their usual traditional beverage made from teff, millet, sorghum, maize and other ingredient.

3.7. Farmer's Traditional Knowledge on Crop Rotation for Soil Fertility Improvement Practice in Relation with Plant Growth Promoting Microbes

Farmers in East & West Gojam Zone were asked awareness about microorganisms like bacteria, fungi, and their role for soil fertility. None of them do have awareness on Microorganisms role in soil fertility, however traditionally they used different techniques to improve soil fertility and increasing teff yield, 80% of respondent tell to renew and increase soil fertility by adding locally made compost, thinning and repeated ploughing for five to seven times, 20% respondent also used by cultivation of some forage plant around farm like Sespania and planting of Bisana (*Croton*

macrostachyus) around their farm. 100% of respondent used crop rotation for soil fertility improvement and teff yield productivity. They respond that especially legume plant have great role in productivity. 92% of respondent of east Gojam mostly used, vetch (*Lathyrus sativus*) niger, (*Guizotia abyssinica*) and 81% of respondent of west Gojam in addition to vetch (*Lathyrus sativus*) niger, (*Guizotia abyssinica*) also used, Barely (*Hordeum vulgare*), Bean (*Phaseolus vulgaris*) Pea (*Pisum sativum*), chickpea (*Cicer arietinum*), and Maiz (*zea mays*) used for crop rotation in teff farm land, 32% respondent also used rotation of different teff cultivar annually to improve their soil fertility and teff productivity (Figure 8). Historically, since the time of the Romans and among indigenous cultures, planting legumes alongside a

cereal crop, especially maize, has been a common practice for centuries [18, 27]. According to [6] Crop rotation is the most efficient economical ways to break through pest and disease, herby making conservation of agriculture feasible. Crop rotation presents several advantage compared to monoculture [6] Crop rotation can help increase soil organic matter, reduces the toxicity of several substances in the soil, by alternating root systems with different characteristics (tap, fascicular) and depths, Improves soil structure, reduce soil erosion and runoff, improve soil physical properties, in addition to that crop rotation is an important strategy in managing insect, disease, and weeds. In addition to that it is very important to improve and keep equilibrium of soil engineer microbes and plant growth promoting microbial community (PGPR). Many studies have been conducted throughout the world on the benefits of growing cereal crops alongside or in rotation with legumes helps to promote PGPR diversity. In a study by [27]. A rhizobia bacterium, the key player in BNF, ensures nitrogen is available to agricultural and garden crops with its symbiotic relationship with the legume. Specificity of the *Rhizobium* species in association to legume species determines the productivity of the nitrogen fixing nodule formed on the legume root. The rhizosphere provides a specialized niche where microbes live and influence crop health and yield and is the zone of the symbiotic relationship between the legume and the microbe. Plant growth promoting rhizobacteria (PGPR) are a heterogeneous group of bacteria that can be found in the rhizosphere, at root surfaces and in association with roots, which can improve the extent or quality of plant growth directly and/or indirectly. In last few decades a large array of bacteria including species of *Pseudomonas*, *Azospirillum*, *Azotobacter*, *Klebsiella*, *Enterobacter*, *Alcaligenes*,

Arthrobacter, *Burkholderia*, *Bacillus*, *Rhizobium* and *Serratia* have reported to enhance plant growth [25]. The indirect promotion of plant growth occurs when PGPR prevent deleterious effects of one or more phytopathogenic microorganisms. (i) the ability to produce or change the concentration of plant growth regulators like indoleacetic acid, gibberellic acid, cytokinins and ethylene [2, 22] (ii) a symbiotic Nitrogen fixation [4], (iii) antagonism against phytopathogenic microorganisms by production of hydrogen cyanide, siderophores production for scavenging iron minerals [30], antibiotics production to control pathogenic fungi [31] and cyanide production for weed and pathogenic fungi control [17] (iv) solubilization of mineral phosphates and other nutrients [14, 21]. Some PGPR may promote plant growth indirectly by affecting symbiotic N₂ fixation, nodulation or nodule occupancy [20]. The most efficient Phosphate solubilizing microbes (PSM) belong to genera *Bacillus*, *Rhizobium* and *Pseudomonas* amongst bacteria, and *Aspergillus* and *Penicillium* amongst fungi. Within rhizobia, two species nodulating chickpea, *Mesorhizobium ciceri* and *Mesorhizobium mediterraneum*, are known as good phosphate solubilizers [29]. Legumes show a high positive response to Phosphate supplementation [19]. A study by [7] Farmers in the study area using Niger, (*Guizotia abyssinica*), Vetch (*Lathyrus sativus*), Pea (*Pistum stvium*), Chickpea (*Cicer arietinum*), maize (*Zea mays*), Barly (*Hordeum vulgare*) for crop rotation to increase soil fertility and teff productivity, these concluded that they indirectly rehabilitate very important plant growth promoting microbial community into the soil having role for nitrogen fixation, phosphate solubilization, phytohormon production, antibiotic production, pathogen inhibitors, sidrophore production.



Figure 8. Farmers frequently used crops for rotation with teff farmland.

1. Niger, (*Guizotia abyssinica*), 2. Vetch (*Lathyrus sativus*), 3. Pea (*Pistum stvium*), 4. Chickpea (*Cicer arietinum*), 5. Maize (*Zea mays*), 6. Barley (*Hordeum vulgare*)

4. Conclusion

Farmers used Niger, (*Guizotia abyssinica*), Vetch (*Lathyrus sativus*), Pea (*Pistum stvium*) Chickpea (*Cicer arietinum*), Maize (*Zea mays*), Barly (*Hordeum vulgare*) for crop rotation to increase soil fertility and Teff productivity. The act of farmer using leguminous crop for crop rotation in teff yield and productivity is due to that they keep the balance of plant growth promoting microbes in the soil. Farmers in East & West Gojam Zone used teff varieties for different purposes, injera making, porrage, gruel, Injera, Qita (unleavened bread), Mekleft (Anebabero) for church ceremony Guberae (Anebabero) for home Consumption, Engocha, Atmit (gruel), Alcoholic drink (Tella) Sprite

(Areke). There are 15 locally known teff variety are cultivated currently these are Magna, Dabo, Kuncho, Sergegna, Nech Bunign, Berenti, Godashigne, Bunigne, Qyelaba, Damenima, Dabo, Minjar, Bost, Avola, Yilmana, Etsub. Both genders that are male and female do have role in teff Farming practice and management. Farmers used traditional equipment for teff farming made from bamboo, wood and iron, Indigenous knowledge is a store of experience and awareness of native society on technologies, practices and beliefs that forms the basis for production of different crops. Farmers' indigenous knowledge on teff production and management system with their selection criteria has tremendous contribution for cultivar development; improved management practices and develops

teff genetic resources conservation strategies, as well as bio fertilizer development for present and future generation.

Recommendation

- Agricultural policies, subsidies and research/extension which promote modern varieties and Farming technologies, at the expense of traditional local knowledge and biodiversity.
- Multiple drivers of loss of traditional knowledge and genetic diversity, which are often inter-linked and mutually reinforcing
- Farmers for making organic fertilizer (compost) is supported by scientific researches as to which identifying the plants that should use as a row material and contain higher proportion of nitrogen and phosphors in its part.
- Soil scientist and microbiologist as well as researcher should study in depth the role microorganisms for soil fertility improvement during crop rotation with teff farming system to produce bio fertilizer based on this traditional Knowledge.

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