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Research Article

Assessment of Indigenous Knowledge of Smallholder Farmers on Intercropping Practices in West Hararghe Zone; Oromia National Regional State, Ethiopia

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The study was conducted in three districts of West Hararghe Zone namely; Gemechis, Habro and Mieso districts. The objectives of the survey were: to identify and document indigenous knowledge of farmers towards intercropping, and identify constraints and opportunities of intercropping in the study area. A multi-stage sampling technique was used for the study. Total sample size of 149 households was interviewed and generated both qualitative and quantitative data. Focus Group Discussions were also formed and generated qualitative data. Descriptive statistics and an index score were used to analyze data. Majorly intercropped crops were Maize with Haricot Bean followed by Sorghum with Haricot Bean. The study indicated that drought, lack of knowledge about fertility management and lack of improved technology of intercropped crops were major constraints of intercropping legumes with other crops in the study area. However, declining of land holding size as a result of rise in population and early maturity of legume cops were major opportunities of intercropping in the study area. The study indicated that any research conducted on any intercropping practice in the area should incorporate farmers practice such as times of sowing and types of intercropped crops on intercropping trial, and awareness on soil fertility improvement should be promoted.

Keywords: Indigenous knowledge, Simultaneously, Double intercropping, Drought, Grain yield reduction

INTRODUCTION

Ethiopia's economy is largely based on agriculture, which provides 80-85% of employment and 61% of the total export (NABC, 2015) and 38.5% of Gross Domestic Product in 2014/15 (NPC, 2016). Hence, the growth of agricultural sector is very important, as it constitutes the bulk of the national economy in terms of human and material resources. However, this sector is characterized by low productivity of land and labor that it failed to make substantial contribution to the country's economic growth and to ensure food self-efficiency (Fenta, 2006).

In Ethiopia absence of effective linkage between indigenous knowledge and conventional ones has been identified as one of the major problems that hinder effectiveness of the development of the agriculture in general and of agricultural research and extension system in particular (Fenta, 2006). The importance of indigenous knowledge has been realized in the design and implementation of sustainable development projects (Ajani *et al.,* 2013). Integration of appropriate indigenous knowledge systems into development programs has already contributed to efficiency; effectiveness and sustainable development impact (World Bank, 2000). Considering such a problem, there had been various attempts both by extension and research organizations to invigorate linkages. Yet, the linkages remain as weak as the number of times solutions were sought to further strengthen them.

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Indigenous knowledge has been defined as institutionalized local knowledge that has been built up on and passed on from one generation to other by words of mouth (Ajani *et al.,* 2013). Indigenous knowledge systems are the complex arrays of knowledge, know-how, practices and representations that guide human societies in their innumerable interactions with the natural milieu: agriculture and animal husbandry; hunting, fishing and gathering; struggles against disease and injury; naming and explaining natural phenomena; and strategies for coping with changing environments (Nakashima and Rou', 2002). It is the basis for local level decision making in many rural communities. Indigenous knowledge has value not only for the culture in which it evolves but also for scientists and planners striving to improve conditions in rural localities. Intercropping is cultivation of two or more crops simultaneously on the same field. It also means the growing of two or more crops on the same field with the planting of the second crop after the first one has completed its development. The rationale behind intercropping is that the different crops planted are unlikely to share the same insect pests and disease-causing pathogens and to conserve the soil.

Intercropping is an important feature of cropping systems in the tropics (Francis, 1986; Connolly, *et al.,* 2001). The common bean (*Phaseolus vulgaris*) and maize (*Zea mays L*.) intercropping is a common feature of crop production in densely populated areas of Eastern Africa such as highlands of Hararghe. The system is very important for the intensification of crop production and contributes to increased returns to small-holder farmers in the highlands of Hararghe having a limited land holding (0.6 ha per house hold size of 5.4 members) (CACC, 2001). Intercropping legumes with non-legume is an important feature of many cropping systems in the tropics (Willey, 1979; CIAT, 1986). There are several socio-economic (Ofori and Stern, 1987), and biological and ecological (Van Rheen *et al.,* 1981; Aggarwal *et al.,* 1992; Chemeda, 1996) advantages to intercropping relative to sole-cropping for small-holder farmers. Introduction of legume-cereal intercropping into mixed farming systems increases farm income and reduces pressure on land resources (Kassie, 2011).

West Hararghe Zone is known to be densely populated area and has limited land holdings and well known for its best practices and indigenous knowledge in different intercropping types. Enhancing the production and productivity in the area with available indigenous technical knowledge will help the improvement of the sector in increasing the sector contribution to National and Agricultural Gross Domestic Product. Identifying and documenting indigenous knowledge of farmers towards intercropping was used to develop appropriate technology for improvement and set clue for police makers to understand gap concerning different practices. Therefore, the study aimed to assess the indigenous knowledge of small-holder farmers towards intercropping practices in the study area.

Objectives of the Study

- ✓ To identify and document indigenous knowledge of farmers towards intercropping
- ✓ To identify constraints and opportunities of intercropping in the study area.

RESEARCH METHODOLOGY

Description of the Study Area

This study was conducted in three districts (Gemechis, Habro &Mieso) of West Hararghe Zone where intercropping practices are known very well. Gemechis is located at 343km East of Addis Ababa and about 17 km South of Chiro, which is capital town of the Zone. The district is bordered with Chiro district in West and North, Oda Bultum district in South, and Mesala district in East. The district is found at altitude ranging from 1300 to 2400msal. Agro-ecologically, the district has three sub-climatic zone highlands (15%), midland (45%) and lowland (40%). The district is mainly characterized as steep slopes and mountains with rugged topography. It receives annual rainfall of 850mm and average temperature of 20^{o}C.

Habro district is located at 404 km to East of Addis Ababa, which is capital city of Ethiopia and 75 km to South of Chiro. The district is boarded by Guba Koricha district in West, Boke district in East, Daro Lebu in South and Oda Bultum in North. Gelamso town is the administrative seat of the district. The altitude of the district ranges between 1600-2400 m.a.s.l. with minimum and maximum temperature of 16^{0}c and 20^{0}c, respectively. The district receives annual rainfall of 650mm to 1000mm (Aman Tufa and Anteneh Temesgen, 2010). Major food crops grown in this district were maize, sorghum and haricot bean, and major cash crops grown were coffee and Khat.

Mieso is located at 304km to East of Addis Ababa and 25km to West of Chiro. It is bordered by Doba district in East direction, Afar Region in West, Chiro district in South and Somali Region in North. The district has an area of 257,344 ha. It is located at the latitude of 9^{o}13’59.99” and longitude of 40°45'0". The altitude of the district on average is 1332 m.a.s.l. with maximum and minimum temperature of 37^{0}C and 25^{0}C, respectively. The annual rainfall of the district ranges from 500mm to 700mm.

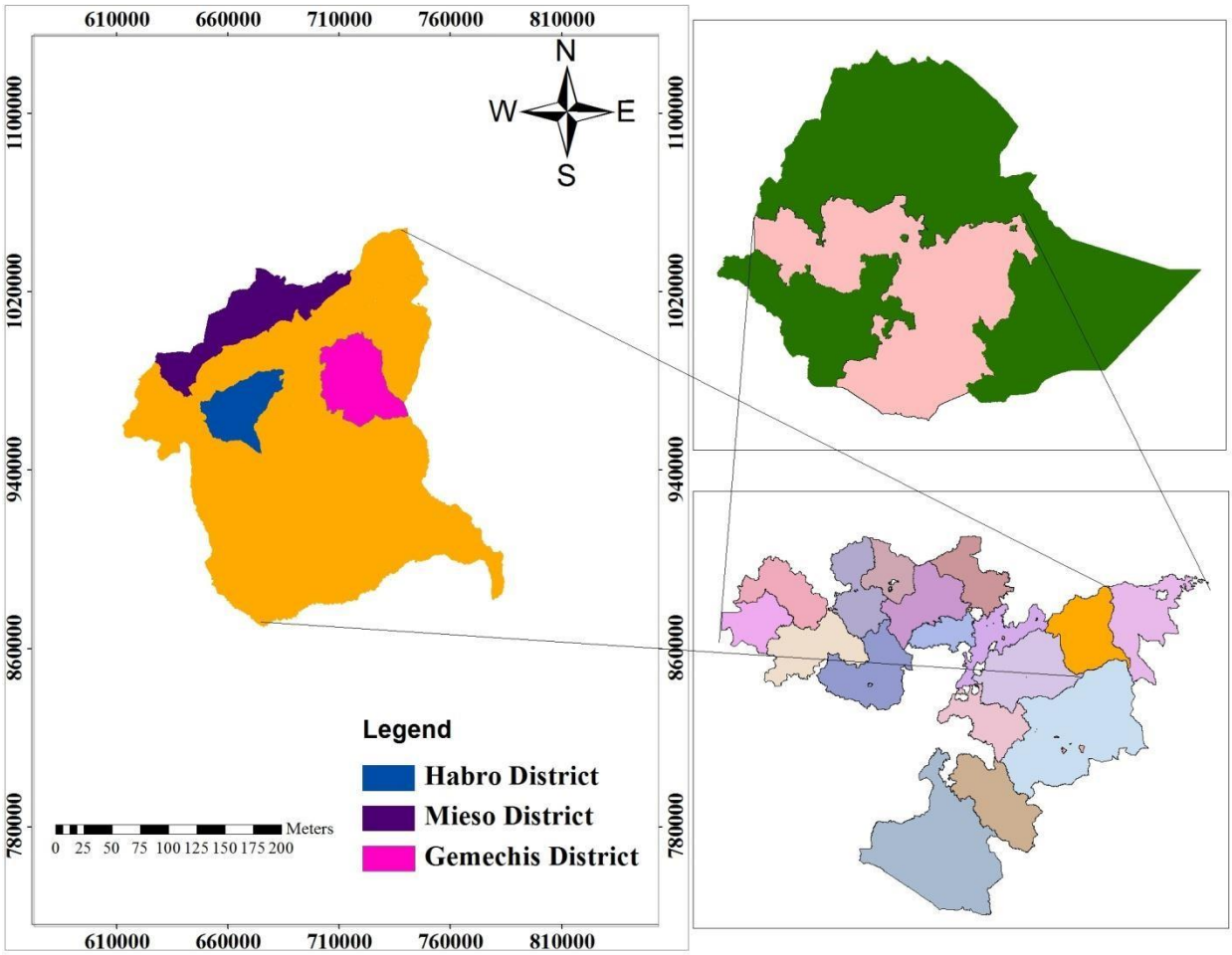

Figure 1: Political map of the study area
Source: Own computation from GIS data, 2017

Sampling Technique

Districts and Kebeles were selected purposively in collaboration with zonal and district Office of Agricultural and Natural Resource depending on their agro-ecology and potential of intercropping practices. Accordingly, Gemechis, Habro and Mieso districts were selected. Then, Oda Bal'a and Gorbo Anani Kebeles from Mieso district, Lelisa and Bareda Kebeles from Habro district, and Kuni Segariya and Hara Bafana Kebeles from Gemechis district were selected. A sample of 149 households which consist 129 male and 20 female were selected randomly by taking in to account probability proportional to population size.

Data Sources, Method of Data Collection and Analysis

Data were collected from both primary and secondary sources. The primary data was collected from 149 sampled households through structured interview schedule. Secondary data was collected from Zonal and District, Agricultural Offices and Natural Resource. Two Focus Group Discussion from each district and generally of six Focus Group Discussion were formed and generated qualitative data. Both qualitative and quantitative data were collected from sampled households through structured interview schedule. Five enumerators were trained and involved in data collection. Data was coded and entered in to SPSS version 20 software for statistical analysis and management. Descriptive statistics such as mean, standard deviation, frequency distribution and percentage were used to understand socio-economic situation and indigenous knowledge of farmers on intercropping practices. An index score was calculated and used to provide overall ranking of major intercropped crops and constraints of intercropping legume crops with other crops. Qualitative data were also analyzed through narration and description.

RESULTS AND DISCUSSION

In this chapter, the results of the study along with previous research findings are briefly presented and discussed as follows.

Demographic and socio economic characteristics of sampled households

Sex, marital and educational status: In this study, of the total interviewed farmers, 86.6% were males, while 13.4%

were females. Regarding marital status, 9.4%, 87.9% and 1.3% of the respondent were single, married, divorced and widowed respectively. Education is a crucial factor for skill development and enhancing farmers' decision making in resource allocation for agricultural activities. Accordingly, the result of the study indicated that about 69.1% of the respondents were literate while 30.9% were illiterate.

Table1: Sex, marital and educational status of the sampled respondents

		Frequency	Percent
Sex	Male	129	86.6
	Female	20	13.4
Marital status	Single	14	9.4
	Married	131	87.9
	Divorced	2	1.3
	Widowed	2	1.3
Educational status	literate	103	69.1
	Illiterate	46	30.9

Source: survey result, 2017

Age, family size and intercropping experience of households: The average age of sampled households in the study area was 39.04 ± 11.24 years and average family size was 6.18 ± 2.38 year. Experience plays an important role in intercropping activities and production efficiency and system of handling of their products. Average years of intercropping experience of households were 16.56 ± 10.45.

Table 2: Age, family size and intercropping experience of households

No.	Variable	Mean ± Standard deviation
1	Age of HHs	39.04 ± 11.24
2	Family size	6.18 ± 2.38
3	Intercropping experience of HHs	16.56± 10.45

Source: survey result, 2017

Total land owned, and allocated for sole cropping and intercropping: Average land holding size of households in the study area was 1.09**±** 0.95Hector, and land allocated for intercropping and sole cropping were 0.77**±** 0.69 Hector and 0.54**±** 0.41 Hector, respectively (Table3). This indicated that land allocated for intercropping exceeds land allocated for sole cropping in the study area.

Table 3: Average land holding, land allocated for intercropping and sole cropping in Ha

No.	**Land**	**Mean ± Standard Deviation**
1	Total land owned	1.09**±** 0.95
2	Land allocated for intercropping	0.77**±** 0.69
3	Land allocated for sole cropping	0.54**±** 0.41

Source: survey results, 2017

Farmers' indigenous knowledge on intercropping practice

Cropping systems: The results of the survey revealed that all sampled respondent were practicing intercropping. Similarly, Gosa Alemu (2016) argued that the major cropping system practiced in the area was intercropping. Major crops which could be grown solely were Sorghum (*Sorghum bicolor*), Maize (*Zea mays*), Onion (*Allium cepa*), Haricot Bean (*Phaseolus vulgaris*), Teff (*Eragrostis abyssinica*), Barely (*Hordeum vulgare*), Faba Bean (*Vicia faba L*.),Wheat (*Triticum aestivum*), Ground Nut (*Arachis hypogaea*), Finger Millet (*Eleusine coracana*), Khat (*Khat edulis*), Chickpea (*Cicer arietinum*), Hot Pepper (*Capsicum annuum*), Sweet Potato (*Lopmoea batatas*) and Pea (*Pisum sativum*).

Table 4: cropping systems practiced by sampled respondents

		Frequency	Percent
Cropping systems	Intercropping only	54	36.2
	Sole cropping and intercropping	95	63.8
	Total	149	100.0

Source: own survey, 2017

Types of intercropped crops in the study area: Themajor intercropped crops in the study area were maize with haricot bean (*Zea mays* + *Phaseolus vulgaris*) followed by sorghum with haricot bean (*Sorghum bicolor* + *Phaseolus vulgaris*) Table 5.Coffee and chat were also intercropped with different crops. Similarly, Tolera and Gebremedin (2015) also reported that coffee was intercropped with different crops such as maize, sorghum and haricot bean in West Hararghe Zone. The reason of intercropping in the study area were; shortage of land (shrinking of cultivated areas per household as a result of rise in population), to maximize profit and to minimize risk. The reasons of intercropping are profit maximization and risk minimization (Ashish *et al.,* 2015 and Tenaw, 2013) and intercropping is an alternative for decreasing of cultivated land per household as a result of increase in population (Getachew *et al.,* 2013) were in line with the reasons of intercropping in the study area. In addition, -availability of khat and coffee, and early maturity of component crops such as haricot bean were also another reason of intercropping in the study area. Khat and coffee are perennial crops and in line with the reality of land shortage in the area, they intercropped with different crops (Table 5).

Table 5: Types of intercropped crops listed and ranked by sampled respondents

No	Intercropped crops-	Intercropped crops by their rank in selected districts			Index score	Rank
		Mieso	Gemechis	Habro		
1	Maize with haricot bean	1		4	0.133	1
2	Sorghum with haricot bean	4	2		0.120	2
3	Maize with haricot bean and barley/teff		1		0.095	3
4	Sorghum with maize and sesame	2			0.089	4
5	Khat with maize and haricot bean			1	0.063	5
6	Sorghum with maize	3			0.051	6
7	Sorghum with maize and haricot bean		3		0.051	6
8	Maize with chickpea			2	0.051	6
9	Coffee with maize and haricot bean			2	0.051	6
10	Khat with haricot bean				0.038	10
11	Khat with maize		4	5	0.038	10
12	Coffee with maize and barley			5	0.038	10
13	Onion with tomato		5		0.032	13
14	Maize with tomato			8	0.032	13
15	Khat with maize and barley			7	0.032	13
16	Sorghum with common vetch			10	0.025	16
17	Coffee with sorghum			9	0.025	16
18	Khat with sorghum			11	0.019	18
19	Coffee with finger millet, sweat potato, chickpea and groundnut			12	0.013	19
20	Khat with finger millet, linseed, sweat potato, chickpea and groundnut			13	0.006	20

Source; survey result, 2017 *Index for a particular intercropped crops = [8 for rank1 + 7 for rank2 + 6 for rank3 + 5 for rank4 + 4 for rank5+ 3 for rank6 + 2 for rank7 + 1 for rank8] divided by sum of [8 for rank1 + 7 for rank2 + 6 for rank3 + 5 for rank4 + 4 for rank5+ 3 for rank6 + 2 for rank7 + 1 for rank8] for all intercropped crops.*

Types of intercropping practiced and times of sowing: Intercropping has four general subcategories. There is mixed, no distinct row arrangement; row intercropping, at least one crop is planted in rows; strip intercropping, growing crops in strips wide enough to separate them yet narrow enough to allow intercropping between them and relay intercropping, growing two or more crops during differing parts of their cycles (Stephen, 2009). Accordingly, farmers of the study area practiced mixed, row and relay intercropping. Coffee and Khat were intercropped with different crops (Table 6) and one up to three rows of different crops were used between coffee or khat rows.

Time of sowing is critical for optimal production of cereal grain with forage legumes (Ashish *et al., 2015*). The best time depends on the cereal and legumes in question and needs to be determined experimentally. Farmers of the study area practiced both sowing simultaneously (at the same time) and at knee height stage (sowing component crops when base crops reach for cultivation). Apart from Gemechis district, in which sorghum is intercropped with haricot bean simultaneously and at knee height stage, the rest have intercropped simultaneously. Sorghum and maize were intercropped simultaneously, and at knee height stage of sorghum and maize, haricot bean was intercropped. Maize was intercropped with haricot bean simultaneously and after haricot bean is harvested in June, either barely or teff is sown in August. Sorghum was also intercropped with haricot bean in April and after harvesting haricot bean in July, again haricot bean is sown in August. This indicated that there is double intercropping practice in the study area. Similarly, Wondimu *et al.* (2016) intercropped maize with soybean simultaneously and indicated that cost of fertilizer is reduced and total productivity is maximized. Tamado *et al.* (2007) also intercropped maize with haricot bean simultaneously and reported the agronomic and economic feasibility of double intercropping of common bean under small holder farming systems of Eastern Ethiopia. On the other hand, Getachew *et al.* (2013) intercropped maize with vetch and lablab fifteen days after emergence of maize, and indicated that row intercropped vetch at 50% seed rate was more advantageous than maize-lablab intercrop. Alemu and Tikunesh (2014) also intercropped maize with forage legumes (*Vigna unguiculata, Lablab purpureus and Vicia atropurpurea*) at knee height stage of maize and suggested that maize grain yield and biomass yield of intercrops can be maximized for both human and livestock feeding by integrating *L. Purpureus* with maize.

Table 6: Spatial arrangement and times of sowing listed by respondents

		Spatial arrangement			Times of sowing		
No	**Intercropped crops**	**Mieso**	**Gemechis**	**Habro**	**Mieso**	**Gemechis**	**Habro**
1	Maize with haricot bean	Mixed			S		
2	Sorghum with haricot bean	Mixed	Mixed		S	S and K	
3	Maize with haricot bean and barley/teff		Mixed			S and double intercropping	
4	Sorghum with maize and sesame	Mixed			S		
5	Khat with maize and haricot bean			Row			
6	Sorghum with maize	Mixed			S		
7	Sorghum with maize and haricot bean		Mixed			S and K	
8	Maize with chickpea			Relay			After maize is matured
9	Coffee with maize and haricot bean			Row			
10	Khat with haricot bean		Row				Haricot bean in April
11	Khat with maize			Row			
12	Coffee with maize and barley			Row			
13	Onion with tomato		Mixed			Onion in July and tomato in August	
14	Maize with tomato			Row			
15	Khat with maize and barley			Row			
16	Sorghum with common vetch			Rely			After sorghum is matured
17	Coffee with sorghum			Row			
18	Khat with sorghum			Row			
19	Coffee with finger millet, sweat potato, chickpea and groundnut			Row			
20	Khat with finger millet, linseed, sweat potato, chickpea and groundnut			Row			

Source; Focus Group Discussion, 2017 Times of sowing: S=Simultaneously; K=Knee height stage

Reduction of yield due to intercropping: The reduction in grain yield due to intercropping may be acceptable to subsistence farmers if it is below (10% - 15%) (As cited in Getachew *et al.,* 2013). Accordingly, 28.4% of the respondent had no willingness to expand intercropping cereal crops with legumes because of drought which intensifies competition for nutrients and grain yield of cereal crops is reduced as a result of intercropping (Table 7). Similarly, Abubeker *et al.* (2006) indicated intercropped lablab depressed grain yield of maize by 26% when planted simultaneously with maize and Wondimu *et al.* (2016) reported that grain yield of maize was significantly reduced by 31.7% due to intercropping with soybean. Contrary, Mergia (2014) indicated that compared to pure stand maize, inclusion of vetch, cow pea and lablab increased grain yield of maize by 7.4%, 5.9% and 5% respectively. It was 71.6% of the respondent that had willingness to continue intercropping of cereal crops with legumes because of land shortage, profit maximization, early maturity of legumes, animal forage, weed control and to reduce risk from crop failure. Intercropping systems resulted into significantly higher productivity (Alemu and Tikunesh, 2014; Hossein *et al.,* 2014; Mergia, 2014; Wondimu *et al.,* 2016 and Tenaw, 2014). Selection of crops that differ in competitive ability in time or space is essential for an efficient intercropping system, and as well as decision on what to plant and at what density.

Table 7: Willingness to expand cereal-legumes intercropping

		Frequency	Percent
Willingness to expand cereal-legumes intercropping	Have willingness	106	71.6
	Have no willingness	42	28.4

Source; own survey, 2017

Major Constraints of intercropping legume crops with other crops

Intercropping of cereal crops with legumes is a widespread focus for current research (Getachew *et al.,* 2013, Douglas, 2014, and Tenaw, 2013). Intercropping of legume crops such as haricot bean, chickpea and vetch are common practice in West Hararghe Zone (Table 8). However, currently, drought was the main constraint of intercropping in the study area. It increases competition among intercropped crops and also because of not raining on time, it reduces the number of intercropped crops. Similarly, Wondimu *et al.* (2016) argued that the lower stand count in intercropped maize compared to sole cropped maize may due to competition for the same resource with soybean or due to shortage of moisture during early vegetative growth. The other constraints of intercropping legumes with other crops in the study area were lack of promotion on intercropping practices and lack of improved technology of intercropped crops (Table 8).

Table 8: constraints of intercropping legume crops with other crops ranked by focus group discussion in the study area

No	Constraints	Rank1	Rank2	Rank3	Rank4	Rank5	Index score	Rank
1	Shortage of improved technology of intercropping	16.67	*	50	*	*	0.167	3
2	Lack of information and knowledge about fertility management	*	*	*	33.33	*	0.048	5
3	Intercropping creates extra work in agronomic management	*	16.67	33.33	*	16.67	0.131	4
4	Lack of promotion (awareness creation) on intercropping of legumes with others	16.67	50	*	16.67	*	0.226	2
5	Drought	66.67	*	*	16.67	*	0.310	1
6	Incompatibility of intercropped crops	*	16.67	*	*	*	0.048	5

Source: own survey, 2017 *Index score for a particular intercropping constraints = [5 for $Rank_1$ + 4 for $Rank_2$ + 3 for $Rank_3$ + 2 for $Rank_4$+ 1 for $Rank_{45}$] divided by sum of [5 for $Rank_1$ + 4 for $Rank_2$ + 3 for $Rank_3$ + 2 for $Rank_4$+ 1 for $Rank_5$] for all intercropping constraints*

Similarly, Douglas (2014) argued that the main reason of not practicing intercropping in Ethiopia has been the promotion of mono-culture by governmental and non-governmental agencies. Intercropping creates difficulty in weeding and cultivation, and shortage of information and knowledge about fertility management were also other constraints of intercropping legumes with other crops in the study area. This result is consistent with the study conducted by Ashish *et al.* (2015) which indicated that one of the disadvantages of intercropping is creating extra work. The study conducted by Wondimu *et al*. (2016), Tenaw (2014), Stephen (2009), Hossein *et al.* (2014) and Getachew *et al.* (2013) indicated that legumes crops improve soil fertility when intercropped with other crops. However, only 39.5% of the respondent knew that legume crops improve soil fertility and 60.5% did know that legume crops improve soil fertility. Biological nitrogen fixation is the major source of nitrogen in legume-cereal mixed cropping systems when nitrogen fertilizer is limited (Ashish *et al.,*2015). Inorganic fertilizers have environmental damage such as nitrate pollution and legumes grown in intercropping are regarded as a suitable and alternative way of introducing N into lower input agro ecosystems.

Opportunities of intercropping practices in the study area

The rising population density and then declining of land holding sizes are compelling the local people to practice intercropping crops for intensively use their land. As a result, intercropping practice can significantly benefit farmers of the study area within the existed land. Expansion of Khat was also another opportunity of intercropping in the study area. Khat is perennial crops and because of land shortage it is intercropped with different crops. The increase in livestock fattening and shortage of animal forage in the area may also increase demand of forage-cereal intercropped technology. In addition, availability of indigenous knowledge on intercropping and accessibility of market for legumes crops like Haricot bean can be another opportunity of intercropping in the study area.

CONCLUSIONS

Intercropping was the major cropping systems in the study area. The reason of intercropping different crops in the study area were; land shortage, profit maximization, risk minimization and availability of perennial crops such as coffee and khat. The major intercropped crops were maize with haricot bean followed by sorghum with haricot bean. Khat and Coffee were planted in rows and intercropped with different crops such as Maize, Sorghum, Haricot Bean, Barely, Groundnut, Finger Millet, Sweet Potato, Chickpea and Linseed. One up to three rows of different crops were intercropped between two rows of coffee or khat. Haricot bean was also intercropped between two plants of coffee. Maize was intercropped with haricot bean simultaneously and after harvesting haricot bean in June, either barely or teff was sown in August. This indicated that there is double intercropping practice in the study area.

Reduction in grain yield due to intercropping, drought, lack of promotion on intercropping practice and lack of knowledge about fertility management were major constraints of intercropping in the study area. However, declining of land holding size as a result of rise in population, expansion of khat and rise in demand for animal forage were major opportunities of intercropping in the study area.

RECOMMENDATIONS

Depending on the results of the finding, the following recommendation has been given to make intercropped technology effective and improve farmers' profit per unit land in the study area.

- ✓ Introduction of improved cereal-legume intercropped technology should be given special emphasis to improve soil fertility and farmers' profit.
- ✓ Strengthening and intensification of compatible intercropped crops should be enhanced.
- ✓ Most of the farmers in the study area were not aware of that legume crops do improve soil fertility. Therefore, awareness creation on soil fertility improvement should be promoted.
- ✓ Haricot bean has been intercropped with cereal crops simultaneously. Therefore, any research conducted on any cereal-legume intercropping should take this practice into account.

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