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Empirical observations of crop and integrated soil fertility management interventions in the central and south western Ethiopia

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ABSTRACT

The introduction of different improved and high yielding crop varieties has increased the possibility of getting improved seed and diversified the cropping systems in the model watersheds. Moreover, the formulation of byelaw has assisted farmers by helping them to transfer seed from farmer to farmer and became accountable for their actions. In regard to this demonstration trial has been made by using random complete clock design. Major crops in the watershed, i.e. Teff and wheat were used with 4 different treatments, negative control, compost, NP and NP & compost. The experiment was analyzed using SAS software. The result shows that there is a significant difference in terms of yield between treatments. The application of inorganic fertilizer alone was significantly superior in yield and plant height. In spite of this the yield gained from both application of compost and inorganic fertilizers should be an option. The research demonstrated that use of organic fertilizer was important aspect of agriculture and efficient ways and agricultural machineries should be developed in order to boost organic farming system in the country. In general female participations and investment on informal education of the farmers is important. Furthermore, strengthening crop production with that of land and erosion management through watershed approaches should be facilitated.

1. INTRODUCTION

In the past four decades, the eastern African highlands have seen rapid population growth and unprecedented land-use changes (Zhou et al., 2004), heightening the challenge of sustaining the resource base while providing for a growing population heavily dependent on natural resources for their livelihoods. Population growth and inheritance practices have contributed to very small household landholdings, reducing incomes and food security and in turn undermining farmers' capacity to invest in conservation activities, often characterized by delayed return.

Most of livelihood in Ethiopia is dependent on Agriculture. The agriculture system encompasses mainly smallholder farmers that hold half GDP (Gross Domestic Product) of the country. It also involves greater than 80 % of the population in 95 % of the total area under crop production and above 90% of crop product (Diao et al., 2007).

The country recognized for the center of origin and diversity for numerous crops. Major cereal crops namely teff, wheat, maize, sorghum and barley sum-up about 86% of the cereal production and enclosed 80% of the overall smallholding practices. These crops are main sources of diet for consumers in rural-urban settings and as well as income for farmers. From year to year through increasing of land area and management practices its production potentials of the crop is increasing (Central Statistical Agency of Ethiopia, 2010)

Conversely, the agricultural system identified by its backwardness in terms of agricultural technologies, unavailability and limitedness of inputs especially inorganic fertilizers. The sector is also affected by deprived infrastructure and unproductive marketing mechanisms (Abrar et al., 2002). In addition, it is challenged by biotic stress and unfavorable environmental conditions. Thus, Ethiopian farmers adopt several coping strategies alongside of overwhelming dynamics such unpredicted environmental condition and production and market instabilities (Rehima et al.,2013).

It been understood that crop diversification is a major approaches in dealing with food insecurity, crop production and market failures. For instance it has been recognized as a means of poverty alleviation in South and South East Asia (FAO and World Bank, 2001).
According to Winters et al, (2006) there are three conditions that satisfies farmers aspire for crop diversity. These are i) risk management, ii) acclimatizing to diverse agro-ecological production sceneries and iii) assuring market demands and food security. As the result, Degye et al, (2012) regarded that through enhancement of crop diversification farmers in Central and Eastern highlands of Ethiopia could be capable of improving food security at household level.

Due to the heterogeneous nature of agro ecology, social and economic conditions agriculture in Ethiopia is highly diversified to address even farmer's consumption and further to market demands. Also it cannot able to resist price fluctuations to manage income risks. Under these cases crop diversification is tailored as essential steps towards shift from subsistence to commercial farming. Similarly this trajectories of farming for own consumption to cash crop production will facilitate smallholder's income (Minot et al., 2006).

Moreover, soil fertility intervention is an important improving mechanism of agricultural production. However, soil fertility Ethiopia has historically been constrained by the lack of an integrated and locally-tailored approach, despite apparent success in individual programs. Studies from Burkina Faso, millet and sorghum yields increased from 400kg/ha in 1984-88 to 650kg/ha in 1996-2000 due to use of stone rows and grass strips for erosion control, along with fertilizer, manure and compost (Gete Zeleke et. al., 2010).

A central objective of this research was to evaluate the diversify of the cropping system and improvement of productivity in the model watersheds, by introduction of different improved and high yielding crop varieties and enhancing soil fertility through integrated management of available organic and inorganic nutrient sources.

2. METHODOLOGY

STUDY AREA

***Borodo* watershed:** - is dominated by cereal based cropping system. It is located in Oromiya regional state in West Showa. Geographically located at $9^{o}01'54''$ N to $9^{o}04'03''$ N and 38^{o} 09' 10" E to 38^{o} 10' 40'' E. It is characterized by an altitude vary from 2211 to 2720 m.a.s.l with the mean annual rainfall of 1139 mm (bio-modal) that drained by *Lugo* river and is sub tributary of Awash basin. The micro-watershed (*Ginichi*) covers only 45 ha while the main watershed (*Borodo*) has an area of 374 ha. The major dominant crops are teff (*Eragrostis teff*), wheat (*Triticum aestivum*) and *chick* pea *(Cicer Arietinum)* and pea *(Pisum sativum).* The dominant soil type is Vertisols and characterized by poor drainage, highly susceptible to erosion and nutrient mining (negative balance) problem. The existing technology and practice in the watershed are grass strips, tree planting at homestead, fallowing, forage development, bunds, compost and using improved varieties. The livestock is predominantly face overgrazing and pasture scarcity.

Girar-Dakuna watershed: - *represents* an enset based cropping system and located in Gurage Zone of *Indibir* district of the Southern Nations and Nationalities and Peoples Region (SNNPR). Geographically located 8^{o} 5' 30'' N to 8^{o} 6' 0'' N and 37 ^{o} 58' 30'' E to 37 ^{o} 59' 0'' E. It is characterized by an altitude vary from 2120 to 2354 m.a.s. l with the mean annual rainfall of 1150 mm (bio-modal). The place is known for Enset (Enset ventricosme) based farming system. It looks a false banana and has an eatable underground part. The dominant type of soil is nitsol and subjected to acidity problems. Average land hold of farmers is very low (0.25 ha) and cultivation practiced commonly in-home gardens.

MATERIAL AND METHODS

Crop Husbandry

Adaptable crop varieties were identified for both watersheds having consultation with researcher, and farmers. Farmers organized in terms of their interest and the team develop guiding byelaw for technology transfer from one farmer to other. Different crop varieties delivered to farmers and at the end of harvesting the seeds returned to other farmers based on the bylaw agreement. Continuous training has been provided for farmers to strengthen their crop production and management practices.

Soil Fertility Management

Farmers were selected to provide training on organic fertilizer preparation. The selection criteria used was their interest on preparation of organic fertilizers and resource availability. Compost were prepared and the main materials used in this activity were ash (saw dust), maize stalks, straw, legumes and farm manure, manure with bedding material, hay from legumes and animal droppings. Air, moisture and temperature were also the most important components of the compost preparation process. Finally, demonstration trials have been conducted at Borodo (Ginchi) on teff and wheat crops comprising four treatments replicated four times in random complete block design. Its analysis made using SAS software (2002).

The treatments are assigned 4x5 meter plot: -

1. Control (Negative)
2. N+ $P_2O_{5\,(}$69/60 Kg NP/ha)
3. Compost (N equivalent)
4. 1/2 (Compost + N+ $P_2O_{5)}$

The recommended N and P were 69 and 60 Kg/ha for the study area. The compost analyzed its N content in the laboratory to calculate the N equivalent. Finally, 17 kg (8.5 ton/ha) and 15 kg (7.5 ton/ha) of compost applied respectively on teff and wheat under treatment three). Whereas half of compost applied in the treatment four with adding half of inorganic fertilizers. The fertilizer applied as per recommended time and the organic fertilizer also applied at planting time.

3. RESULT AND DISCUSSION

3.1. Crop diversification and Soil fertility management trend

From the Table 1, three major crops at Borodo have been introduced. Organic and inorganic inputs have been used by farmers to obtain the indicated result. The amount of yield gained from the three crops is below the average yield gained from research field and it is subjected to management practices used by the participant farmers.

Table 1. Major improved crop varieties introduced in the model watersheds.

No	Watersheds	Type of crop	Variety	Av. Yield (Qt/ha)	Participant farmer		
					Male	Female	Total
1	Borodo	Teff	Kuncho	9.65	30	4	34
		Wheat	Digelu	22	14	1	15
		Chick pea	Arerti	20	9	1	10
2	Girar Dakuna	Barley	HB1307	12.76	12	6	18
		Wheat	Digelu	29	43	18	61
		Potato	Jaleni	-	10	1	11
		Enset	Tadelech	-	15	3	18

However, the average yield of wheat at Girar Dakuna is very high as compared to Borodo watersheds since their farms were rich in nutrient due to very close to homestead. Also, potato and Enset were introduced to Girar dakun farmers and commonly that used for home consumption.

From table 2, 60 farmers from Borodo watershed has got training on preparation, use and management of inorganic fertilizers. Out of the trainees, 50 were males and 10 were female. Ten farmers out of which 7 were male and 3 females had prepared high quality 150 kg compost after they attend the training and have also shared experiences with other local farmers in

the watershed. However, in Borodo watershed farmers use animal manure and it ranges in to 23.7 ton.

Table 2. Training participant and compost making trend at Borodo and Girar Dakuna watershed

Watershed	Training participated		Compost prepared		Organic fertilizer utilization trend (ton) (animal manure)
	M	F	M	F	
Borodo	50	10	7	3	23.7
Girar -Dakuna	25	5	-	-	-

In Girar Dakuna Watershed trainings to 30 farmers (25 male and 5 female) have been given on the preparation and usage of organic fertilizer. Farmers at Girar Dakuna watershed didn't use any inorganic fertilizers in their farming practices. This may be due to less crop and livestock production since the source of inorganic fertilizers came from those practices.

Table 3. Effect of nutrient management on Teff and Wheat plant height (PH), biomass and grain yield (BY/GY)

Teff				Wheat		
Treatment	**PH (cm)**	**BY (kg/ha)**	**GY(kg/ha)**	**PH (cm)**	**BY (kg/ha)**	**GY(kg/ha)**
Control	85.50^{c}	2356.30^{c}	734.30^{c}	58.63^{c}	1444.40^{c}	498.90^{c}
N+ P_2O_5	114.25^{a}	4512.00^{a}	1561.60^{a}	86.13^{a}	5163.70^{a}	1880.06^{a}
Compost	86.00^{c}	2439.80^{c}	764.10^{c}	58.70^{c}	1636.90^{c}	515.96^{c}
½ Compost + N+ P_2O_5	93.25^{b}	3292.10^{b}	1150.60^{b}	77.00^{b}	2877.00^{b}	1410.07^{b}
Mean	94.75	3150.07	1052.64	71.11	2780.49	1076.24
CV (%)	4.5	11.7	14.1	2.4	10.57	11.54
P- Value	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
LSD	6.8074	591.31	238.9	2.7042	470.35	198.78

From the demonstration trial application of inorganic fertilizer alone are significantly superior in yield and plant height than the other treatments on teff and wheat. Teff yield is increased by 113%, 3.6% and 57% and similarly wheat yield increased by 276%, 3.4 and 18% % compared to the control due to the usage of inorganic, organic and a combination of two respectively. As shown from table 3, in spite of this the yield gained from both application of compost and inorganic fertilizers should be used as an option.

Table 4. Soil chemical characteristics of the trial sites before application of treatments

Teff	PH	PPM	% TN	% OC	Wheat	P^H	PPM	% TN	% OC
Control	6.4	12.12	0.08	1.4	Control	6.28	6.2	0.08	1.19
N+ P_2O_5	6.44	10.15	0.08	1.31	N+ P_2O_5	6.29	6.51	0.09	1.35
Compost	6.43	13.21	0.08	1.47	Compost	6.27	5.88	0.09	1.44
½ (Compost + N+ P_2O_5	6.47	13.08	0.08	1.42	½ (Compost + N+ P_2O_5	6.25	7.24	0.08	1.39

Before the experiment all soil parameters of P^H, the rate of Phosphorus /PPM/ , percentage of total nitrogen and organic carbon were analyzed. As indicated from table 4, revealed that the field used for experimentation is almost uniform.

Table 5. Effects of different soil fertility management treatments on soil chemical properties after harvesting of Teff and Wheat

Teff						Wheat				
Treatment	P^H	PPM	Kmeq/ 100g	%OC	%TN	P^H	PPM	Kmeq/ 100g	%OC	%TN
Control	6.31	7.89	0.86	0.95	0.08	5.89	5.43	0.99	1.09	0.083
N+ P_2O_5	5.80	8.2	0.82	0.91	0.08	5.91	6.86	0.83	1.09	0.083
Compost	6.34	8.04	0.85	1.05	0.078	5.94	5.31	0.87	1.04	0.078
½ (Compost + N+ P_2O_5	6.32	7.68	0.89	0.99	0.08	5.89	5.49	0.8200	0.99	0.08
Mean	6.19	7.95	0.85	0.98	0.08	5.90	5.77	0.88	1.05	0.08
CV (%)	7.99	15.07	3.92	7.69	6.62	2.75	24.14	17.94	16.56	6.62
P- Value	0.3829	0.9363	0.0579	0.1310	0.5221	0.9680	0.4016	0.4328	0.7977	0.5221
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

As shown from table 5, the soil chemical property after harvesting is not significant between treatment despite there is a significant yield difference (table 3). This is might justify that the field selected for the experiment is rich in soil nutrient and the uptake(need) by the crop is below the amount of organic and inorganic fertilizer added in the soil. The nature of nutrient added form and crop demand contribute the availability and absorption of nutrients.

4. CONCLUSION AND RECOMMENDATION

The introduction of improved crop varieties plays a major role as a way to increasing production and diversifying cropping system. Land degradation and soil erosion should be minimized along with considering crop diversity through promoting watershed approaches. Thus ongoing soil and water conservation efforts should be made more strategic than campaign works.

Females should be considered while recognizing their contribution on crop diversification through polices and promotion and empowerment of females to participate in homestead agriculture by accessing available resources, technology, credit, and other facilities. Training and experience sharing mechanisms is pivotal for crop diversification. Thus, investment on informal farm school should be considered as a way for facilitating awareness creations.

Even though the change in crop productivity in the country is came from use of improved variety, and inorganic fertilizer applications, the important of organic fertilizers were underestimating in the farming community. The study has demonstrated that integration of both fertilizers can increase crop yield and farmers would have options to cultivate crops. But the preparation of compost is tiresome and farmers fear to make compost with wrong perceptions. It is therefore better to consider the safest and easy means of compost preparations and design of agricultural implements.

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