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EVALUATIONS OF INTEGRATED SOIL FERTILITY MANAGEMENT INTERVENTIONS TO ENHANCE CROP PRODUCTIVITY IN THE CENTRAL HIGHLAND OF ETHIOPIA

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Abstract
Soil fertility in Ethiopia has historically been constrained by the lack of an integrated and locally-tailored approach, despite apparent success in individual programs. The experiment has been made at Borodo watershed in the central highland of Ethiopia to evaluate soil fertility through integrated management of available organic and inorganic nutrient sources. Major crops in the watershed, teff (Eragrostis tef) and wheat (Triticum aestivum L.) were used with 4 different treatments, negative control(No fertilizer and compost),NP(Nitrogen and Phosphorus fertilizers), compost, NP and compost replicated four times in a random complete block design. 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. Although, result showed that use of inorganic fertilizer is superior for teff and wheat yield, the alarming cost of fertilizer constrain farmers in using inorganic fertilizers. Moreover, use of inorganic fertilizer devastates the soil fauna and flora. Hence integration of organic and inorganic fertilizer is essential for sustainable intensification in the study area. We also conclude that full packages of integrated soil fertility technologies should be developed considering different agro-ecologies of the country.

Key Words: *Organic fertilizer, Inorganic fertilizer, Teff, Wheat, Yield*

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. Agriculture is the predominant activity for most rural households in Ethiopia. The sector is mainly based on small holder farms and contributes about half to the total Gross Domestic Product (GDP) of Ethiopia and the livelihoods of more than 80% of the citizens (Diao *et al*., 2007). The small-scale farming accounts for 95% of the total area under crop and more than 90% of crop output.

Land degradation and decline in soil fertility have become serious threats to agricultural productivity in Sub-Saharan Africa. The declining fertility of soils because of soil nutrient mining is regarded as a major cause of decreased crop yields and per capita food production in Africa; and decreasing soil fertility accompanied with increasing population pressure is one of the major causes of the gap between demand for and supply of food (Endrias Geta *et al.*, 2013).

However, the sector is characterized by poor and backward technology, acute shortage of purchased inputs, particularly fertilizer, poor infrastructure and inefficient marketing systems (Abrar *et al*., 2002). The adverse effects of abnormal weather are also very common in Ethiopia. Ethiopian farm households use diverse farm systems as an insurance against uncontrollable factors such as weather, production and market fluctuations.

Studies have indicated that the integration of organic and inorganic fertilizer and practices can provide to twofold the crop yield as compared to fertilizers applied separately (Getachew and Taye, 2005; Vãje, 2007; Dercon and Hill, 2009). However soil fertility in 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 *et al*., 2010). With above premise this research was carried out to evaluate soil fertility through integrated management of available organic and inorganic nutrient sources.

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 9º01′54″ N to 9º04′03″ N and 38º 09′ 10″E to 38º 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 (bi-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.

Experimental Design

Compost was prepared and the main materials used in this activity were ash (sawdust), 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 as a test crop with four treatments that replicated four times in a random complete block design in the experiment. Each plot represented 4x5 meter square and list of the treatments presented below;

1. Negative Control (No fertilizer and compost)
2. N+ P_2O_5 (69/60 Kg NP/ha)
3. Compost (N equivalent)
4. 1/2 (Compost + N+ P_2O_5)

Improved seeds of Kuncho (teff) and Digelu (wheat) varieties were row planted by 20 cm row spacing at seed rate of 7 and 150 kilogram/ hectare, respectively. The recommended N and P (69/60 Kg N/P/ha) was applied from Urea and DAP. The compost analyzed its N content in the laboratory to calculate the N equivalent. Finally, 17kg per plot (8.5 ton/ha) and 15 kg per plot (7.5 ton/ha) compost were applied for teff and wheat plots, respectively. For T4, half of compost and inorganic fertilizers were applied on teff and wheat field. The fertilizer applied as per recommended time and the organic fertilizer also applied at planting time. Relevant data's were collected and analyzed by SAS (Statistical analysis software). The SAS statistical computer package (SAS, 2002) was used to test for presence of outliers and normality of residuals. The total variability for each trait was quantified using analysis of variance with the following model (Gomez and Gomez, 1984). Results were presented as means and least significance difference (LSD) at 5% probability level was used to establish differences among means, and linear regression was performed between biomass and grain yield.

Result and Discussion

For all yield and yield components, application of inorganic fertilizer is significantly higher than the other treatments both in teff and wheat crops (Table 1). Inorganic fertilizer increased teff yield by 113% and wheat yield by 277%. Integration of organic and inorganic fertilizers increased teff yield by 57% and wheat by 183%. Although, the effect of integrating compost and inorganic fertilizer is not as effective as sole inorganic fertilizer, it will have long lasting and sustainable effect on crop yield, soil fauna and flora.

Table 1: Effect of nutrient management on Teff and Wheat plant height (PH), biomass yield (BY) and grain yield (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

The linear regression analysis showed that teff and wheat grain yield is positively correlated with total biomass (R^2=0.968, 0.879) respectively (figure 1). The highest biomass production is a common phenomenon on teff than wheat. However due to low lodging effect on teff the yield obtained was higher.

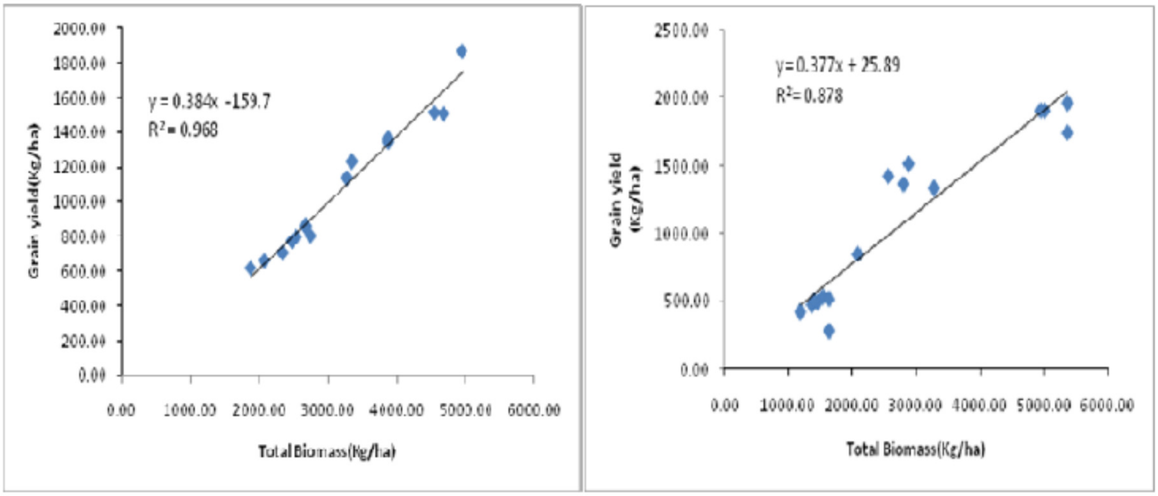

Fig. 1: Correlation of teff (left) and wheat (right) grain yield with total biomass

Before the experiment all soil parameters of pH (Power of hydrogen measures acidity and alkalinity), the rate of phosphorus part per million (ppm), percentage of total nitrogen (%N) and organic carbon (% OC) were analyzed. As indicated from table 2, revealed that the field used for experimentation was almost uniform despite phosphorus rate were different and high on teff experimental plot.

Table 2: Soil chemical characteristics of the trial sites before application of treatments

Teff	pH	P(ppm)	% TN	% OC	Wheat	pH	P(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 +	6.47	13.08	0.08	1.42	½ (Compost +	6.25	7.24	0.08	1.39
N+ P_2O_5	6.43	12.14	0.08	1.4	N+ P_2O_5	6.27	6.45	0.85	1.34

As shown from table 3, despite the significant yield difference (table 1), the soil chemical property after harvesting were not significant different between treatment. This might justify that the fields selected for the experiment were poor in soil nutrient and the uptake (need) by the crop was equivalent to the amount of organic and inorganic fertilizer added in the soil. The nature of nutrient, added form and crop demand may contribute the availability and absorption capacity.

Conclusion and Recommendation

Although, result showed that use of inorganic fertilizer is superior for teff and wheat yield, the alarming cost of fertilizer constrain farmers in using inorganic fertilizers. Moreover, use of inorganic fertilizer devastates the soil fauna and flora. Hence integration of organic and inorganic fertilizer is essential for sustainable intensification in the study area. However, farmers fear to make compost with perceptions that the preparation of compost is tiresome. It is therefore essential that government and non-government development actors create awareness regarding the preparation and advantage of compost. It is also important to consider the easiest means of compost preparations and design of agricultural implements. We also conclude that full packages of integrated soil fertility technologies should be developed considering the agro-ecologies of the country.

Table 3: Effects of different soil fertility management treatments on soil chemical properties after harvesting of teff and wheat

	Teff					Wheat				
Treatment	pH	P(ppm)	Kmeq/ 100g	%OC	%TN	pH	P(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	0.820	0.99	0.080
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	6.9
P- Value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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