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Evaluation of enriched farmyard manure and inorganic fertilizers profitability in hybrid maize (BH-140) production at west Hararghe zone, eastern Ethiopia

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Abstract

Soil fertility depletion on smallholder farms is one of the fundamental biophysical root causes responsible for declining food production in Africa particularly in Ethiopia. The Hararghe highlands, eastern Ethiopia is one of the regions characterized by ragged topography which is highly subjected to soil erosion and rampant nutrient depletion. Thus, low soil fertility is a major constraint in maize production and productivity on smallholder farms. This situation prevails despite the fact that farmyard manure which can be used as an alternative cheap source of nutrient is readily available. A study was conducted at the Haramaya University Chiro Campus to evaluate the profitability of enriched farmyard manure and inorganic fertilizers on grain yield of maize. Farmyard manure was used either alone or in combination with inorganic fertilizers as follows: control (zero fertilizers and farmyard manure), 10tons/ha FYM, 8tons/ha FYM and 25kg/ha of N + 20kg/ha P, 6tons/ha FYM, 50kg/haN + 40kg/ha P, 4tons/ha FYM, 75kg/ha N + 60kg/ha P, 2tons/ha FYM , 100kg/ha N+80kg/ha P 100kg/ha N + 100kg/ha P. The treatments were arranged in randomized complete block design with four replications from 2008 to 2010.Economic analyses were done using BCR and NBCR. Result from the combined analysis of variance on hybrid maize (BH-140) yield over years showed the presence of no significant difference between 10tons/ha FYM and 100kg/ha N +100kg P/ha treatment combination ($p<0.05$). But economic analysis on the basis of BCR and NBCR showed the presence of significant difference between these treatment combinations. 4tons/ha FYM combined with 75kg/ha N+60kg/ha P was found to be the most profitable and economical treatment combination. However, analysis of BCR and NBCR indicated the presence of no significant differences among 10tons/ha FYM, 8tons/ha FYM and 25kg/ha of N + 20kg/ha P, 6tons/ha FYM, 50kg/haN + 40kg/ha P and 2tons/ha FYM, 100kg/ha N + 80kg/ha P treatment combinations whose net benefit cost ratios were 0.86, 1.07, 1.00 and 1.99, respectively. These four options were recommended for dissimilation in eastern Ethiopia. On the basis of these results, it can be concluded that enriched FYM can be used for hybrid maize production at western Hararghe in order to get maximum grain yield and maximum farm return. Thus, it is recommended that application of 4tons/ha FYM incorporated with 75kg of N and 60kg of P is the most economical and profitable treatment combinations in boosting hybrid maize (BH-140) yield and in sustaining its productivity over years.

Keywords: Profitability, Farmyard manure, Hybrid maize, Inorganic fertilizers, Benefit cost ratio.

Introduction

Maize is one of the most important cereals broadly adapted worldwide (Christian *et al.*, 2012). In Ethiopia, it is grown in the lowlands, the mid-altitudes and the highland regions. It is an important field crop in terms of area coverage, production and utilization for food and feed purposes. However, maize varieties mostly grown in the highlands (altitude 1,700 to 2,400 m.a.s.l.) of Ethiopia are local cultivars with poor agronomic practices (Beyene *et al.*, 2005). They are low yielding, vulnerable to biotic and abiotic constraints and also exhibit undesirable agronomic performances such as late maturity and susceptibility to root rot and stalk lodging (Fininsa, 2001; Beyene *et al.*, 2005; Legesse *et al.*, 2007). Enhancement of maize production and productivity can be achieved through identification of potentially superior inbred line combinations in the form of hybrids (Bernardo, 1999; Alexander and Bindiganavile, 2004) along with proper supplementation of plant nutrition. Intensive cultivation of high yielding maize varieties requires application of plant nutrients in large quantities (Mosisa *et al.*, 2007). Supplying these nutrients from chemical fertilizers has got certain limitations and inherent problems (Debelle *et al.*, 2001). Further, these chemical fertilizers can supply only a few plant nutrients like nitrogen, phosphorus and potash. Non-inclusion of organic manures such as farmyard manure, compost, green manures, etc. in the manurial schedule have resulted in the depletion of fertility status of the arable soils and their consequent degradation (Agele *et al.*, 2005; Pulleman *et al.*, 2003; Chen *et al.*, 1998).

One way of replenishing nutrients in the arable lands is to recycle nutrients through application of organic material such as litter, crop residues, and manures (Lekasi *et al.*, 2000; Agele *et al.*, 2005). Organic manures, especially farmyard manure, have a significant role for maintaining and improving the chemical, physical and biological properties of solis (Pulleman *et al.*, 2003). Organic materials play a critical role in sustainability in the arid and semi-arid regions (Heluf *et al.*, 1999). Despite this importance, there is little predictive understanding for the management of organic inputs in arid and semi-arid agro ecosystems. It is now widely recognized that soil organic matter plays an important role in soil chemical (pH, base saturation, salinity and CEC changes) physical (bulk density, stabilization of soil structure and aggregate formation) properties (Pulleman *et al.*, 2003; Wakene *et al.*, 2001) and biological properties. Farm yard manure prepared from cattle manure is the most important organic soil amendment utilized in east Africa region (Lewandowski *et al.*, 1999). According to Wakene *et al.* (2005) farmers from the western part of Ethiopia are experiencing low maize yields due to deterioration of both chemical and physical soil properties due lack of organic matter. Similarly Heluf (2002) reported grain yield of maize at Hirna valley, west Hararghe zone is very low due to low soil fertility status. But after application of FYM grain yield of maize has increased over the control plots at Hirna (Heluf, 2002; Asfaw *et al.*, 1998). Total organic matter has long been recognized as an important determinant of soil performance. Its influence depends on the amount of organic matter added to the soil, its decomposition rate, and the amount held by the soil. The amount, type, and location of organic matter may be one of the best integrating indicators of many physical, chemical and biological processes in the soil system (Lewandowski *et al.*, 1999; Wakene *et al.*, 2005; Agele *et al.*, 2005; Elfstrand *et al.*, 2007). Presently the arable land in eastern part of Ethiopia is decreasing as a result of population pressure; therefore there is a need to increase production per unit area to secure food self-sufficiency and food security (Zelalem, 2012). Maize (*Zea mays* L.) being a heavy feeder of plant nutrients in the soil requires high supply of external mineral nutrients in the form of inorganic fertilizers or organic manure (Mosisa *et al.*, 2007). The crop production system with high yield target cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrient removed by crops (Rijpma and Jahiruddin, 2004; Hoffman 2001).

Decline in soil fertility and high cost of inorganic fertilizers are limitations to maize yield improvement in Ethiopia (Mosisa *et al.*, 2007; Heluf, 2002; Debele *et al.*, 2001; Wakene *et al.*, 2005 and Wakene *et al.*, 2001). Khaliq *et al.* (2009) used partially decomposed cattle and chicken manure amended with wood ash and reported that higher plant yield of fodder maize by the use of chicken manure. Manure can supply nutrients required by crops and replenish nutrients removed from soil by crop harvest.

Organic amendments, such as FYM are known to improve soil physical properties (Marinori *et al.* 2000). Organic matter is an important soil constituent influencing a number of constraints linked with crop productivity. The loss of soil fertility, in many developing countries, due to continuous nutrient depletion by crops without adequate replenishment poses an immediate threat to food and environmental security. Intensive cropping and tillage system have led to substantial decreases in soil organic matter levels of much prime land in the world. This decrease in soil organic matter levels seems to be associated with the decline in soil productivity. Hence, the application of FYM is essential for maintaining soil fertility (Lewandowski *et al.*, 1999). From western part of Ethiopia Wakene *et al.* (2005) and Debele *et al.* (2001) reported the benefit of FYM in maize production and soil maintainace. Similarly Zelalem (2012) investigated that grain yield of hybrid maize (BH-140) and its harvest index increased as a result of FYM application along with inorganic fertilizers over control plots at west Hararghe zone. Therefore, promoting cheaper substitute or supplement to inorganic fertilizers will boost maize yields in the smallholder farms in the zone. However, farmers in Hararghe area are reluctant to using negligible quantities of animal manures or crop residues because most of these materials are being used for cooking, house building and cattle feed (Heluf *et al.*, 1999; Ararsa, 2012) which results in poor soil organic matter development in the region resulting in low level of hybrid maize yield.

Hence, there is a strong need to encourage the use of organic manure on maize production in smallholder farms of this region. However, the economics for the use of FYM in combination with inorganic fertilizers or at sole level in maize production is of great importance. Benefit cost ratio (CBR) which can be defined as the total discounted benefit divided by the total discounted cost (Kruse, 2004) is an important parameter since it determines the viability of a project. The project is considered viable if, and only if the BCR is greater than one (Miller, 2001). But no investigation was made on economic profitability of FYM usage at eastern part of Ethiopia. Therefore, the objective of this investigation was to evaluate profitability of enriched farmyard manure and inorganic Fertilizers in hybrid maize (BH-140) production at west Hararghe zone, eastern Ethiopia**.**

Materials and Methods

Description of the Study Area: West Hararghe is located between 7^0 55′ N to 9^0 33′ N latitude and 40^0 10′ E to 41^0 39′E longitude. The major crops grown in the study area are sorghum, maize, chat, field beans, potato and tef. The area is characterized by Charcher Highlands having undulating slopes and mountainous in topography. The mean annual rainfall ranges from 850 to 1200 mm/year with minimum and maximum temperatures of 12^0 C and 27^0 C, respectively.

Treatment Details: The response of hybrid maize variety (BH-140) was used as test crop, to N and P fertilizers. Farmyard manure was used either alone or in combination with inorganic fertilizers as follows: control (zero fertilizers and farmyard manure), 10tons/ha FYM, 8tons/ha FYM and 25kg/ha of N + 20kg/ha P, 6tons/ha FYM, 50kg/haN + 40kg/ha P, 4tons/ha FYM, 75kg/ha N + 60kg/ha P, 2tons/ha FYM , 100kg/ha N+80kg/ha P 100kg/ha N + 100kg/ha P. The treatments were arranged in randomized complete block design with four replications at the Haramaya University Chiro Campus from 2008 to 2010 cropping seasons.

Experimental Procedures: The experimental field was prepared by using local plough according to farmers' conventional farming practices. The field was ploughed four times each year during the experimental seasons. A plot size of 4 m length by 4.5 m width with six rows per plot was used. Spacing was 0.75 m and 0.25 m between rows and plants, respectively. Planting was done in May 2008, 2009, 2010 and 2011 at a rate of 25 kg/ha. Enriched FYM was prepared by adding 10 kg of urea by pit method in12m^3 pit from cattle manure subjected to microbial fermentation for 90 days (Debelle *et al.*, 2001; Achieng et al., 2010). Urea (46-0-0) and DAP (46-18-0) were used as sources of N and P, respectively. All P fertilizer and half dose of N fertilizer as per treatment were applied as basal application at planting and the remainder N was top-dressed at 35 days after planting and FYM was applied each year one month before the sowing date. Seeds of hybrid maize (BH-140) were sown on 10^{th} of May 2008, at 20^{th} of May 2009 and 15^{th} of May 2010 at the rate of 25kg/ha. Sowing was completed on the same day. Then after, all necessary cultural practices were employed to raise a successful crop. An area of 5.65 m^2, corresponding to 32 plants in the central four rows, was harvested immediately after physiological maturity for grain yield. During harvests, border plants at the ends of each row were excluded to avoid border effects. Grain moisture percent (MOI %) was estimated using a Dickey-John multi grain moisture tester. Grain yield (GY t ha-1) was calculated using shelled grain and adjusted to12.5% moisture (Mosisa *et al.*, 2007). Economic analysis of the treatments was done by benefit cost ratio method. That is the total return of maize from a unit area divided by the total cost of producing it.

Results and Discussion

Effect on Grain Yield from the Application of FYM and Inorganic Fertilizers: Combined analysis of variance on grain yield of hybrid maize (BH-140) over years showed the presence of no significant difference between treatments 2 and 7 (10t/ha FYM and 100kg/ha N +100kg /ha P) (Table 2 and Table 3) and also the result indicated that all proportions of farmyard manure and inorganic fertilizer treatments significantly increased maize grain yield as compared to the control treatment (Table 1 and Table 2) and the highest grain yield (8158.5 kg/ha) was obtained in the treatment 5 (4 ton/ha farmyard manure+75kg/ha N and 60kg/ha P) and the lowest grain yield (1647.5 kg/ha) was obtained in the control plots (Table 1). The analysis of variance also elucidated the presence of no significant difference among treatment 2, 6 and 7(10t/ha FYM+0 N and P, 2t/ha FYM and 100kg/ha N + 80kg/ha P and100kg/ha N + 100kg/ha P), respectively (Table3) at ($p<0.05$) on grain yield of hybrid maize (BH-140). But 4ton/ha FYM and 75kg/ha N+60kg/ha P increased maize yield from 5.1t/ha in 2009 to 8.15t/ha in 2010 (Table 1 and Table 2).

Table (1): Effect of enriched FYM and inorganic fertilizers on grain yield of hybrid maize (BH-140) at Chiro, Western Hararghe, Ethiopia from 2008 to 2010.

Treatments	Mean grain yield of maize (kg/ha)					
	Rep 1	Rep 2	Rep 3	Rep 4	Total	Mean
Control(0 FYM and 0 N and P)	1563	1784	1586	1657	6590	1647.5
10t/ha FYM	6579	6934	6601	6496	26610	6652.5
8t/ha FYM and 25kg/ha N + 20kg/ha P	5546	5955	6266	5661	23428	5857
6t/ha FYM and 50kg/ha N + 40kg/ha P	5497	5353	4978	4854	20682	5170.5
4t/ha FYM and 75kg/ha N + 60kg/ha P	7601	8155	8042	8836	32634	8158.5
2t/ha FYM and 100kg/ha N + 80kg/ha P	7269	6837	6228	6340	26674	6668.5
100kg/ha N + 100kg/ha P	6568	6821	7343	7256	27988	6997
Total	4063	41839	41044	41100	164606	6858.58
CV(%)	5.43					
LSD=0.05	571.53					

Table (2): Mean separation (Duncan's Multiple Range Test) for the effect of enriched farmyard manure and inorganic fertilizers on grain yield of hybrid maize (BH-140) at West Hararghe Zone, Oromia, eastern Ethiopia (2008 to 2010).

	1647.5	6652.5	5857	5170.5	8158.5	6668.5	6997
1647.5	0	-5005*	-4209.5*	-3523*	-6511*	-5021*	-5349.5*
6652.5		0	795.5^{ns}	1482^{ns}	-1506*	-16*	-344.5*
5857			0	686.5^{ns}	-2301.5*	-811.5*	-1140*
5170.5				0	-2988*	-1498*	-1826.5*
8158.5					0	1490^{ns}	1161.5^{ns}
6668.5						0	-328.5*
6997							0

Table (3): Economic analysis on the use of FYM and inorganic fertilizers on hybrid maize (BH-140) production at western Hararghe, eastern Ethiopia (2008 to 2010)

Operation cost(Birr/ha)	Control	2tons/ha FYM+100kg/ haNand 80kg/ha P	4tons/ha FYM+75kgN and 60kg/ha P	6tons/ha FYM+50kgN and 40kg/ha P	8tons/ha FYM+25kgN and 20kg/ha P	10tons/ha FYM	100kg/ha N and 100kg/ha P
Land preparation	2000	2000	2000	2000	2000	2000	2000
BH-140 seed	1435	1435	1435	1435	1435	4135	1435
Planting	1200	1200	1200	1200	1200	1200	1200
Fertilizers							
DAP	0	624	468	312	156	0	780
UREA	0	560	432	280	140	0	560
Labour for FYM	0	1500	3000	4500	6000	7500	0
Fertilizer application	0	820	820	820	820	820	820
First weeding	620	620	620	620	620	620	620
Second weeding	480	480	480	480	480	480	480
Third weeding	420	420	420	420	420	420	420
Harvesting	780	2480	2752	2145	2280	2480	2526
Yield (kg/ha)	1647.5	6652.5	8158.5	5170.5	5857	6652.5	6997
Total returns at (5.5 Birr/kg)	9061.25	36588.75	44871.75	28437.75	32213.5	36588.5	38483.5
Total cost	6935	12229	13627	14212	15551	19655	10841
Net benefit	2125.25	24359.75	31244.75	14225.75	16662.5	16933.5	27642.5
Benefitcost ratio (PVB/I)	1.30	2.99***	3.29*	2.00****	2.07****	1.86****	3.54**
NBCR(BCR-1)	0.30	1.99	2.29	1.00	1.07	0.86	2.54

Assumtions:*Wage rate=25 Birr/man-day, 2010 rate, *Fertilizer cost (DAP) =780Birr/100kg, 2010 price *Urea=560Birr/100kg, 2010 price, *Maize price=5.5Birr/kg, *Discount rate=15%

Economic Analysis: Result from the combined analysis of variance on hybrid maize (BH-140) yield over years showed the presence of no significant difference between 10tons/ha FYM and 100kg/ha N +100kg P/ha treatment combination ($p<0.05$). But economic analysis on the basis of BCR and NBCR showed the presence of significant difference between these two treatment combinations (Table 3). 4tons/ha FYM combined with 75kg/ha N+60kg/ha P was found to be the most profitable and economical treatment combination. However, analysis of BCR and NBCR indicated the presence of no significant differences among 10tons/ha FYM, 8tons/ha FYM and 25kg/ha of N + 20kg/ha P, 6tons/ha FYM, 50kg/haN + 40kg/ha P and 2tons/ha FYM, 100kg/ha N + 80kg/ha P treatment combinations whose net benefit cost ratios were 0.86, 1.07, 1.00 and 1.99, respectively (Table 3). The highest BCR (2.54) was observed on application of 100kg/ha N and 100kg/ha P on sole basis and the lowest value of BCR (0.3) was noted on the control plots (Table 3).

Low soil organic matter content is the main cause of low productivity, and it is considered as one of the most serious threats to the sustainability of agriculture in Ethiopia. Balance fertilization using both organic and chemical fertilizers is important for maintenance of soil organic matter (OM) content and long term soil productivity in the tropics where OM content is low. Heluf *et al.* (1999) reported that most soils from the eastern part of Ethiopia have less than 1.7% and some soils have less than 1.0% organic matter. Therefore, Application of FYM is considered as a traditional way of returning organic matter to the soil. It is believed that adding considerable quantities of FYM to agricultural land will reverse the trend of soil organic matter reduction from the soil system.

Leonard (1986) reported FYM manure has been recognized as a valuable source of plant nutrients for crops and Kumar *et al.* (2004) indicated that FYM manure is a potential source of plant nutrients like nitrogen (0.84 to 1.21%) phosphorus (0.91 to 1.07%) and potassium (1.35 to 2.35%). FYM manure application registered over 53% increases of N level in the soil, from 0.09% to 0.14% and exchangeable cations increase with manure application (Wakene, 2005). Materechera and Salagae (2002) concluded balanced and integrated use of organic and inorganic nutrient sources may help sustain crop production. The integrated use of organic nutrient sources with inorganic fertilizer was shown to increase the potential of organic fertilizer and improve the efficiency of inorganic fertilizer. Tsidale (1985) and Chapagain (2010) indicated the availability of soil N is enhanced by addition of manures, presumably due to chelation of cations by organic acids and other decay products. Experiments conducted by wakene *et al.* (2005) and Wakene *et al.* (2001) indicated that application of FYM manure registered higher uptake of NPK than control in maize at western part of Ethiopia and a yield advantage of over 67% which is in agreement with this finding. Similarly Heluf (2002) reported a yield advantage of 53% from the application of FYM over the control plots substantiating the findings of the present experiment.

Analysis of BCR and NBCR from this experiment indicated the presence of no significant differences among 10tons/ha FYM, 8tons/ha FYM and 25kg/ha of N + 20kg/ha P, 6tons/ha FYM, 50kg/haN + 40kg/ha P and 2tons/ha FYM, 100kg/ha N + 80kg/ha P treatment combinations whose net benefit cost ratios were 0.86, 1.07, 1.00 and 1.99, respectively (Table 3). The highest BCR (2.54) was observed on application of 100kg/ha N and 100kg/ha P on sole basis and the lowest value of BCR (0.3) was noted on the control plots (Table 3). Therefore farmers from the eastern part of Ethiopia can choose the treatment combination which can fit to their level of economic status to reap maximum advantage from the production of BH-140. In this finding it is indicated that yield advantage does not necessarily show economic advantage. Therefore to test the best economic fit of farm productivity it is a must to undertake economic analysis at farm level using profitability indicators like the benefit cost ratio analysis.

Conclusions

From this finding four treatment options are recommended for dissimilation in eastern Ethiopia. On the basis of these results, it can be concluded that enriched FYM can be used for hybrid maize production at western Hararghe in order to get maximum grain yield of BH-140 and maximum farm return. Thus, it is recommended that application of 4tons/ha FYM incorporated with 75kg of N and 60kg of P is the most economical and profitable treatment combinations in boosting hybrid maize (BH-140) yield and in sustaining its productivity over years.

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