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Review Article

Integrated Soil Fertility Management in Improving Maize Production in Ethiopia

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Abstract

The productivity of maize in potential agro-ecologies has been notified in decreasing trends, mainly because of declining soil fertility. To alleviate this production problem in the country, commercial fertilizers have been relied to boost the productivity of maize that commonly cultivated in continuous production system. The research outputs of various institutions in the country confirmed variable results because of differences in soil types, agro-ecology, varieties used and crop management systems. Maize planted using combinations of FYM, compost, biogas effluent, crops with lower rates of NP fertilizers at Bako and enriching FYM at Chiro with inorganic fertilizers gave comparable yield to the recommended NP rates. The uses of legumes as short fallows and green manuring indicated that mucuna at Bako and sesbania at Jimma, planted Legumes as precursor crop at Bako could partially or fully replace the N-fertilizer need of subsequently sown maize. At Hawassa also nine t ha^{-1} coffees by product combined with 60 kg N ha^{-1}enhanced soil fertility and promised sustainable production of maize in respective location.

Keywords: Compost; FYM; ISFM; Maize

Introduction

Maize (*Zea mays* L.) is one of an important food crops in Ethiopia. It is also the most important cereal crop in terms of area coverage, production, and economic importance in Ethiopia [14]. According to ATA (2013/14) maize occupied 2 million hectares (ha) of land with estimated average yield of 3.2 tons (t) ha^{-1}. This is far below the world average 5.1 t ha^{-1} [10]. One of the major constraints affecting maize production and productivity is declining soil fertility and inadequate crop management [9].

In Ethiopia, Maize is cultivated in all of the major agro ecology zones up to altitudes of 2400m.as.l. The maize growing areas in Ethiopia are broadly classified in to four ecological zones; high altitude moist (1800-2400 m.a.s.l.), mid altitudes moist (1000-1800 m.a.s.l.), low moist (below 1000 m.a.s.l.) and moisture stress (500-1800 m.a.s.l.) [8]. In this agro-ecology, pressure on land to put under cultivation has been increased in time series with raising population and following by gradual reductions of fallow periods. In addition, maize has been cultivated continuously on the same piece of land and most of these areas are characterized by cereal-livestock farming systems where free grazing animals remove more of crop residues than are returned in to soils for nutrient recycling, and aggravate soil erosion and high loss of nutrients [30]. It has also been observed that crop rotations are very rarely practiced and legumes are absent in the system [24]. However, commercial fertilizers have been relied to boost the productivity of maize in continuous cropping systems. Eventually, escalating costs of inorganic fertilizers may not encourage the purchasing potential of resource poor farmers. In this trend most farmers use to apply sub-optimal doses of fertilizers to their crops.

To restrain this emerging problem in the country, the use of mineral fertilizers has started since 1952 following the establishment of agricultural schools and experimental stations. Subsequent, extensive and nation-wide fertilizer studies have been made by different organizations [17]. According to the same source these earlier efforts have resulted in a blanket recommendation of 100 kg DAP ha^{-1} for most cultivated crops in all agro-ecologies of the country. The two types of fertilizers namely; urea and DAP (Diammonium phosphate) have been widely used than any other fertilizer in the country [6]. Moreover, most recent mineral fertilizer research attempts that have been done on maize at different research institutions confirmed variable results, mainly because of differences in soil types, agro-ecology, varieties used and crop management systems. Therefore, salient mineral fertilizer recommendations that primarily based on N and P rates have been offered for different maize producing regions of Ethiopia [29]. Although, continuous use of commercial fertilizers alone has caused adverse effect on soil nutrient balances and, reduced plant growth performance. Moreover, the use of chemical fertilizers alone might have also resulted in a possible depletion of essential micronutrients thereby resulting in an overall reduction in total crop productivity. This further justifies the need to use organic fertilizers. Re-

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search efforts made on different sources of organic fertilizers to show bright scenario for maize production in smallholder fields [34]. This authors reported that legume rotations, integrated use of mineral and organic fertilizers, green manure legumes resulted in enhanced soil fertility and promised smallholder farmers to produce maize at low cost. In addition they help to increase organic matter content of the soil which in turn improves the physic-chemical characteristics of the soil notably, increase water holding capacity of the soil. They also improve the nutrient retention property of the soil serve as reservoir of the micronutrients and reduce leaching losses of nutrients [31]. Besides, they increase the fertilizer use efficiency of crops [13].

Modern nutrient management strategy has shifted its focus towards the concept of sustainability and eco-friendliness. Integrated use of various soil fertility amendment inputs aims at alleviating the limiting nutrients problem and improves their availability through interactions with the mineral soil and reducing the P adsorption capacity of the soil. The integrated nutrient management paradigm acknowledges the need for both organic and inorganic mineral inputs to sustain soil health and crop production due to positive interactions and complementarities between them [20]. The objective of this paper is to review integrated soil fertility management options for sustainable maize production in Ethiopia.

Literature Review

Indigenous Knowledge of Maintaining Soil Fertility

Being in the tropics, most Ethiopian soils are very poor in their inherent soil fertility [18]. However, they were able to sustain crop production in the far past due to useful indigenous knowledge of soil fertility restoring practices mainly shifting cultivation, manuring, use of various food legumes mainly in the maize-based cropping system and the retention of crop residues after crop harvest in the farms [4]. However, some four decades back these traditional and natural ways of soil fertility restoration practices have been abandoned adversely affecting crop production. A brief description is given of these methods and their role on mainta in soil fertility is discussed.

Shifting Cultivation: In most parts of sub-Saharan Africa and indeed the eastern Africa region, the most common traditional farming systems were all variations of shifting cultivation [12]. In these traditional cultivation systems, recuperation of soil fertility was accomplished within a period of 15-20 years bush fallow which allowed crops to be grown without the use of fertilizers [21].

The shifting cultivation involved clearing part of the forest vegetation (approximately 0.5 ha), followed by burning when the mass of vegetation was dry and leaving the ash on the surface. Planting was done using digging sticks after the onset of the rains and weeding was done by slashing. The soils were therefore not disturbed between planting holes. Cultivation was done for 3-4 years and the fields would be abandoned. A bush would then develop from the stumps and large roots left after clearing the previous fallow and seeds from adjoin forest [11]. The regrowth of the secondary forest, initially composed of light-loving plant species, would then develop followed by slower-growing species and after 20 years the secondary forests were indistinguishable from the original forests [3]. The major mechanisms of nutrient transfer from the vegetation to the soil during the development of the secondary forest are mainly, stem flow, litter fall, timber fall and root decomposition. With adequate fallow periods of 15-20 years and a low population pressure density, shifting cultivation was capable of maintaining crop production and soil fertility [20]. With the increase in population pressure, the fallow periods are in most cases absent or too short to regenerate soil fertility adequately for improved crop productivity.

Application of Farmyard Manures: Applying Farm Yard Manure (FYM) locally called as *'Dike'* is one of the most useful and significant indigenous methods practiced almost in all the villages of the country. Application of FYM is a practice which involves using of fully decomposed organic matter of livestock dung, straw, grasses, left over feed etc. The leaves used for animal bedding are also used for making organic manure. The preference towards leaves used for cattle bedding depends upon the availability of resources in nearby forests. The quantity of FYM used for field application depends upon the number of livestock reared, proximity to the forest, extent of land as well as the manpower available. With the application of FYM, earthworms also get introduced in the cropland and increase the fertility of the soil. FYM has been used in many parts of sub-Saharan Africa as a key resource for sustaining soil fertility. Manures are an important source of major and minor nutrients and have also been used to improve soil physical and chemical properties [22]. FYM therefore play a major role in improving crop productivity for the resource poor farmers of the sub-Saharan Africa.

Mixed Cropping and Crop Rotation

In the past, farmers within the central Ethiopian highlands used to grow a wide range of food legumes, mainly intercropped with maize. The legumes included cowpeas (*Vigna unguiculata* L.), pigeon peas (*Cajanus cajan* L.) and dry beans (*Phaseolus vulgaris* L.). Legumes root symbioses provide N_2 through biological nitrogen fixation. The legumes can therefore use fixed N rather than soil mineral N [2].

Legumes cannot always supply enough N to meet all the internal plant needs by symbiotic nitrogen fixation. This is true for legumes because, nodule activity decreases during the grain filling period when there is an increasing completion of reproductive structures with the nodules for a diminishing photosynthetic supply. Nevertheless, some food legumes are more efficient in N_2 fixation than others under a given set of environmental conditions. For example, cowpeas are estimated to fix between 73-80 kg N ha^{-1}, pigeon peas between 65-85 kg N, while dry beans inoculated or un inoculated have sometimes failed to fix N [19].

Modern Concept of Maintaining Soil Fertility

Integrated Nutrients Management:

Integrated Use of Cropping Systems with Inorganic Fertilizers and Farmyard Manure: Low soil fertility is one of the major factors limiting crop production and productivity in small holder maize based cropping systems in Ethiopia. Inorganic inputs fertilizers in continuous cropping systems have limited ability for long-term maintenance of soil fertility [35]. Legume-cereal sequence is one of the cropping pattern practices on smallholder farmers' in Ethiopia. Crop rotation sequences incorporating legumes can be used to effectively restore, maintain, enhance soil fertility and built up the N status of the soil. Besides, reduced dependence on chemical fertilizers crop rotations that favour nitrogen fixation will benefit both agriculture and environment and should be integrated in cropping systems [35].

The study carried out at Western Oromia, on identifying the best precursor crops and optimum integrated of farmyard manure and inorganic fertilizer in maize based rotation sequence show that Haricot bean, Niger seed followed by application of either 12 t ha-1FYM or 89-35NP$_2$O$_5$ kg ha^{-1} is a better option for sustainable maize production than continuous mono cropping [1]. The study carried out by the same authors on similar location on best compatible soybean varieties in intercropping systems and the most economically optimum integrated fertilizer from soybean (Didessa variety) without affecting yield of the maize.rate show that were significant differences in leaf area index, plant height and grain yield of maize due to integrated fertilizer application. Integrated use of 55/23 N/P$_2$O$_5$ kg ha-1 with 8 t ha^{-1} FYM also revealed better economic advantage with some additional yield

Integrated use of inorganic and organic fertilizers: Integrated use of organic and inorganic fertilizers is much better than single use of either chemical fertilizer or organic ones in maize cropping systems. It increases fertilizer use efficiency, reduces risks of acidification, and provides a more balanced supply of nutrients [28]. Organic manures and residue also improve physical and chemical properties of soil and fertilizer use efficiency when applied in combination with mineral fertilizers [5]. There are a number of researches done by different scholars to address the problems of soil fertility, on locally available sources of organic fertilizers for continuous basis for replenishing the degraded physicochemical properties of soils to make sustainable maize production in Ethiopia. Accordingly, a study carried out on integrated uses of NP and FYM at five locations in western Oromia indicated that integrated application are better than application either NP or FYM alone [33] (Table 1). Other studies at the same location revealed that FYM has to be applied every three years at the rate of 16 t ha^{-1} supplemented by NP fertilizer annually at the rate of 20-46 N-P$_2$O$_5$ kg ha^{-1} (Table 2) for sustainable maize production around Bako and similar areas [27].

Table 1: The effects of FYM and NP fertilizers on maize grain yield at five locations in the 1997 cropping season.

N/P + FYM (kg ha^{-1} + t ha^{-1})	t maize grain ha^{-1}					
	BRC*	Walda	Shoboka	Harato	Laga Kalla	Mean
0/0 + 0	0.90^{h}	4.68^{e}	4.44	5.79^{d}	1.86^{f}	3.53^{g}
0/0 + 4	3.61^{g}	6.68^{ab}	6.43	7.72^{abed}	4.37^{cde}	5.76^{ef}
0/0 + 8	4.87^{cdef}	6.50^{abc}	6.52	5.74^{d}	4.41^{cde}	5.61^{f}
0/0 + 12	5.05^{cde}	6.71^{ab}	6.95	6.78^{d}	4.17^{de}	5.93^{def}
20/20 + 0	3.79^{fg}	6.70^{ab}	6.88	6.20^{d}	4.75^{bcd}	5.66^{ef}
20/20 + 4	4.69^{defg}	7.44^{ab}	7.82	6.96^{cd}	3.27^{e}	6.04^{def}
20/20 + 8	6.50^{ab}	6.88^{ab}	7.44	8.94^{abc}	4.35^{de}	6.82^{bc}
20/20 + 12	6.50^{ab}	5.76^{bc}	6.52	7.28^{bcd}	4.75^{bcd}	6.16^{cdef}
40/25 + 0	4.33^{efg}	6.12^{abc}	6.70	9.06^{ab}	4.46^{cde}	6.13^{cdef}
40/25 + 4	5.05^{cde}	5.71^{bc}	8.00	6.78^{d}	4.66^{bcd}	6.04^{def}
40/25 + 8	5.96^{bc}	7.98^{a}	7.64	7.57^{abcd}	5.67^{abc}	6.96^{ab}
40/25 + 12	5.96^{bc}	6.88^{ab}	7.44	6.00^{d}	5.44^{abcd}	6.34^{bcde}
60/30 + 0	4.51^{efg}	6.52^{abc}	6.52	7.68^{abcd}	5.04^{bcd}	6.06^{def}
60/30 + 4	5.77^{bcd}	7.05^{ab}	7.47	7.68^{abcd}	4.67^{bcd}	6.53^{bcd}
60/30 + 8	7.40^{a}	6.52^{abc}	6.88	7.34^{bcd}	5.85^{ab}	6.80^{bc}
60/30 + 12	6.78^{ab}	7.80^{a}	7.64	9.58^{a}	6.61^{a}	7.68^{a}
LSD (5%)	1.24	1.86	NS	2.02	1.32	0.72
CV (%)	14.54	16.87	24.00	16.59	17.05	16.45

*BRC: Bako Research Center; means within a column followed by the same letter(s) are not significantly different at the 0.05 level

Source: Wakene *et al.,* [33]

Table 2: Effects of farmyard manure and inorganic fertilizers on maize at Bako, 1992-1995.

	Year				
FYM-N-P2O5 (t-kg-kg ha-1)	1992	1993	1994	1995	Mean
0-0-0	28.3	33.0	21.3	23.0	26.4
0-10-23	31.2	38.0	35.8	29.3	33.8
0-20-46	33.6	43.2	39.8	33.7	37.6
8-0-0	38.8	38.0	32.7	29.2	34.7
8-10-23	26.1	40.6	40.7	35.7	35.8
8-20-46	26.5	48.5	56.1	44.2	43.8
16-0-0	31.3	45.8	40.4	35.0	38.1
16-10-23	35.4	51.2	56.2	44.5	46.8
16-20-46	31.5	56.7	58.7	50.0	49.2
24-0-0	32.5	43.8	47.1	41.0	41.1
24-10-23	28.1	53.3	54.4	48.5	46.1
24-20-26	35.7	54.5	61.1	55.4	51.7
0-75-75	54.4	54.6	60.9	55.9	56.5
LSD (0.05)	6.39	5.68	5.56	5.94	4.93

Source: Tolessa *et al.,* [27]

At Bako, a trial was executed on uses of biogas effluent as organic fertilizer with integration of NP rates. The biogas effluent brought significant change in chemical composition of the soil in particular, soil organic carbon was fairly increased [26]. After application the integration of both fertilizers was observed to produce significantly higher grain yield. Although 12 t ha^{-1} biogas effluent alone gave higher yields that were comparable to other treatments, biogas effluent applied at 8 t ha^{-1} with 55/10 kg NP ha^{-1} was selected as the best alternative fertilizer combination and thus, recommended for maize production in Bako areas (Table 3).

The study carried out by Zelalem (2013), on integrated uses of enriched farmyard manure and inorganic fertilizer at Haramaya University Chiro Campus also shows that enriching FYM with inorganic fertilizers can boost hybrid maize grain yield significantly through improving the physicochemical properties of the soil (Table 4). The application of 4 tons/ha FYM incorporated with 75 kg of Nitrogen and 60 kg of Phosphorus at Chiro can significantly increase hybrid maize (BH -140) yield and sustain its productivity over years. Besides, it also reduces the cost of inorganic fertilizers which is becoming a bottle neck to smallholder farmers of Eastern Ethiopia.

Integrated use of improved fallow of mucuna [*Mucuna pruriens* (L) DC] with NP fertilizers enhanced soil chemical properties mainly soil pH, basic cations and reduced exchangeable acidity and increased uptake of nitrogen, phosphorus, and

Table 3: Combined effects of biogas effluent and NP fertilizer rates on grain yield of maize at Bako.

BE ha^{-1} t ha^{-1} and NP rates kg ha^{-1}	Grain yield (kg/ha)			
	2001	2002	2003	Mean
4 t BE ha^{-1} + 50 % RR NP kg ha-1	8998	6741	2668	6135
4 t BE ha^{-1} + 75 % RR NP kg ha-1	9609	6623	3154	6462
4 t BE ha^{-1} + 100 RR NP kg ha-1	9568	7556	2812	6645
8 t BE ha^{-1} + 50 % RR NP kg ha-1	9837	7846	4357	7346
8 t BE ha^{-1} + 75 % RR NP kg ha-1	9061	8204	3575	6947
8 t BE ha^{-1} + 100 % RR NP kg ha-1	9662	7628	3698	6996
12 t BE ha^{-1} + 50 % RR NP kg ha-1	9549	7821	3326	6899
12 t BE ha^{-1} + 75 % RR NP kg ha-1	9389	7537	3709	6878
12 t BE ha^{-1} + 100 % RRNP kg ha-1	9923	9395	4187	7835
12 t BE ha^{-1}	9216	7840	5131	7396
RR NP kg ha^{-1} (110/20)	9894	6265	2051	6070
16 t BE ha^{-1}	8332	9023	4664	7340
LSD<0.05	1126	2106	1503	NS

BE: Biogas Effluent; RRNP: Recommended Rate of Nitrogen and Phosphorus

Table 4: Effect of enriched FYM on grain yield (mean values) of hybrid maize (BH-140) at Chiro, Western Hararghe from 2008 to 2011.

Treatment	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+0 N and P	6579	6934	6601	6496	26610	6652.5
8 t/ha FYM and 25 kg/ha N + 20 kg/ha P	5546	5955	6266	5661	23428	5857
8 t/ha FYM and 50 kg/ha N + 40 kg/ha P	5497	5353	4978	4854	20682	5170.5
4 t/ha FYM and 75 kg/ha N + 60 kg/ha P	7601	8155	8042	8836	32634	8158.5
2 t/ha FYM and 100 kg/ha N + 80 kg/ha P	7269	6837	6228	6340	26674	6668.5
100 kg/ha N + 100 kg/ha P	6568	6821	7343	7256	27988	6997
Total	4063	41839	41044	41100	164606	6858.58

Source: Zelalem, [36], FYM: Farmyard Manure

Table 5: Effects of integrated management of mucuna fallow with NP fertilizer on plant height and maize grain yield at Bako.

Treatment	Plant height (cm)				Grain yield (t ha^{-1})			
	2001	2002	2003	Mean	2001	2002	2003	Mean
Control	250	277	201	242	2.3	2.7	1.7	2.2
IF	295	312	248	285	4.0	4.3	5.9	4.7
IF + 55/10 NP	347	304	269	311	7.9	4.0	5.8	5.9
IF + 37/7 NP	339	319	248	297	7.7	3.8	5.9	5.8
IF + 4 t ha^{-1} FYM	340	317	274	312	7.4	4.9	6.4	6.3
IF + 2.7 t ha^{-1} FYM	341	318	270	309	6.3	4.3	7.3	6.1
110/20 kg h^{-1} NP	336	318	251	301	5.5	3.3	4.5	4.4
LSD <0.05	39.3	ns	34.8	18.9	1.4	ns	1.8	0.9

Source: Wakene *et al.* [32]. IF = improved fallow with *Mucuna* green manure, FYM: Farm Yar Manure; LSD: Least Significant Difference; ns: Not Significant

potassium in maize [32]. The integrated use of these organic sources with inorganic fertilizers significantly improved maize grain yield over the control and recommended rate of inorganic fertilizers (Table 5). During three cropping seasons (2001 to 2003) the use of short fallow of mucuna alone increased maize grain yield by 111% over the control. Therefore, short fallowing of mucuna along with FYM or with low dose of NP fertilizers may be used as low cost intermediate technology for enhancing soil fertility and increased maize yield and also grantee sustainable maize production in western Ethiopia.

Other study carried out by Merkebu and Ketema during 2009 main rainy season at Mizan ATVET college, on the effects of Green Manure (GM) and Nitrogen (N) levels on yield related

Table 6: Grain yield (kg/ha) of maize as affected by the interaction effect of applied N fertilizer and green manure.

	Green manure rates (ton/ha)			
N levels (kg/ha)	0	5	10	Mean
0	1847e	2084d	2042d	1990.7
20	2083de	2083d	3472b	2546.0
40	2777c	3514c	4208ab	3499.7
60	3611b	3792bc	4625a	4009.3
Mean	2579.5	2868.0	3586.8	
LSD (0.05)	582			
CV (%)	11.22			

N: Nitrogen; CV: Coefficient of Variation; LSD: Least Significant Difference

traits and yield of maize, inorganic nutrient source applied in sole and in combination with organic have improved most of the yield related traits and yield of maize (Table 6). The application of 10 tons/ha GM incorporated with 60kg N/ha at Mizan Teferi, South-west Ethiopia can significantly increase maize yield and sustain its productivity over years.

The work of Tesfa *et al*. (2004) by using of Sesbania biomass and dried FYM with total Nitrogen (N) contents of 2.25% and 1.25% respectively at Jima during 1999 and 2000 main cropping season indicate that maize exhibited very attractive performance on plots that received the highest rate of sesbania and farmyard manure. Subsequently, at the same rate both gave significantly higher mean grain yield of 7.10 t ha^{-1}. Application of sesbania biomass and dry FYM greater than five t ha^{-1} gave comparable or greater maize yield to 69 kg N ha^{-1} from urea fertilizer. The grain yield gains due to N from organic sources were 50% and 40% as compared to the control and N received plots, respectively (Table 7). Five ton per hectare can definitely substitute the N-requirement of maize and determined to be a minimum dry weight to incorporate to soil for legumes and well managed FYM of total N-contents of greater than 2.5% and 1.25% respectively. Therefore, these should be advised for low cost and sustainable maize production in areas similar to Jima.

At Hawassa, integrated uses of coffee by product and N fertilizer were evaluated to enhance low soil fertility and produce information on low input maize cropping system. Combinations of different rates of coffee by product and N rates were tested

Table 7: Minimum total dry biomass of a legume and FYM required for enhanced maize production.

Available Inputs	Cropping seasons		Mean	% increase
	1999	2000		
5 t ha^{-1} sesbania	6.41	6.28	6.34ab	46
10 t ha^{-1}sesbania	7.19	6.96	7.08a	63
5 t ha^{-1}farmyard manure	5.82	6.04	5.93bc	36
10 t ha^{-1} farmyard manure	6.83	7.53	7.18a	65
69 kg ha^{-1} N	5.52	4.45	5.04cd	16
0 kg ha^{-1}N	4.59	4.1	4.34d	-
Mean	6.06	5.91		

Figures followed by the same letters are not significantly different at p<0.01
Source: Tesfa et al., [25]

Table 8: Effect of coffee by product and N fertilizer on grain yield (kg ha-1) of intercropped maize.

Coffee by product (t ha^{-1})	N fertilizer (kg ha^{-1})				
	0	30	60	90	Mean
0	1541	3540	3911	4044	3259 b
3	2237	3600	1985	3244	2766 c
6	2800	3289	2755	3866	3177 b
9	3807	3348	3659	4133	3737 a
Mean	2596 d	3444 b	3077 c	3822 a	

Means followed by same letters denote no significant difference between treatments (P>0.05).
Source: Tenaw et al., [23]

Table 9: Effect of integrated use of compost and low doses of NP fertilizers on maize grain yield.

NP kgha-1 + compost th-^{1}	Bako	Kejo	Anno
0/0 + 0	4025b	3670c	3740d
0/0 + 5 compost	5450ab	5340b	4730c
25/11 N/P + 5 compost	5840ab	6600a	5680b
55/10 N/P + 5 compost	6990a	6120a	6510a
110/20 N/P + 0	6490a	7350a	6850a

Means within a column followed by the same letter(s) are not significantly different at P<0.05
Source: Wakene et al., [34]

in maize-common bean intercropping system. Significant increment of grain yield of maize was obtained where nine ton per hectare coffee residue without N fertilizer applied. The same treatment had yield advantage of 91% over the control (Table 8). While N fertilizer alone accounted for 149% yield advantage over the control. Likewise, combinations of coffee by product and nitrogen had greater yield advantage up to 213% over the untreated control. Application of N fertilizer raised the uptake of N up to 60 kg ha^{-1}. Therefore, coffee growers in southern region can sustain their maize production system through integrated uses of 90 kg N ha^{-1} with six ton ha^{-1} coffee by product.

Other study by Wakene *et al*. (2004) around Bako on integrated use of compost and mineral fertilizer in 2000 and 2001 cropping seasons. The combined analysis of maize grain yield across location and season showed significant differences ($P \leq 0.05$) among the treatments. The recommended rate of NP (110/20 kg N/P ha^{-1}) gave the highest mean grain yield, though five tons ha^{-1} compost integrated with 25/11 kg N/P and 50/10 kg N/P ha^{-1}produced comparable average maize grain yield (Table 9). Therefore, use of five tons ha^{-1} of compost with 55/10 kg of N/P ha^{-1} is found economical for maize production in western regions.

Summary and Conclusion

The productivity of maize in potential agro-ecologies has been notified in decreasing trends, mainly because of declining soil fertility. In the past farmers used traditional methods of soil fertility restoring practices.

These methods have been abandoned and adversely affecting maize production. To alleviate this production problem in the country, commercial fertilizers have been relied to boost the productivity of maize that commonly cultivated in continuous production system. However, increasing costs of chemical fertilizers may not encourage the smallholder farmers to use the full recommended dose for their maize, research efforts has been made on integrated uses of different sources of organic and inorganic fertilizers to offer low input technology for soil fertilization.

The research outputs of various institutions in the country confirmed variable results because of differences in soil types, agro-ecology, varieties used and crop management systems. Maize planted using combinations of FYM, compost, biogas effluent, crops with lower rates of NP fertilizers at Bako and enriching FYM at Chiro with inorganic fertilizers gave comparable yield to the recommended NP rates. The uses of legumes as short fallows and green manuring indicated that mucuna at Bako and sesbania at Jimma, planted Legumes as precursor crop at Bako could partially or fully replace the N-fertilizer need of subsequently sown maize. At Hawassa also nine t ha^{-1} coffees by product combined with 60 kg N ha^{-1}enhanced soil fertility and promised sustainable production of maize in respective location.

References

1. Zerihun A, Abera T, Dedefo T, Fred K. Maize yield response to crop rotation, farmyard manure and inorganic fertilizer application in Western Ethiopia. African Journal of Agriculture. 2013; 8: 5889–95.

2. Agbede TM, Ojeniyi SO, Adeyemo AJ. Effect of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum in Southwest, Nigeria. America and Eurasian Journal of Sustainable Agriculture. 2008; 2: 72–7.

3. Altieri MA. The ecological role of biodiversity in agro ecosystems. Agriculture, Ecosystems & Environment. 1999; 74: 19–31.

4. Aulakh MS, Khera TS, Doran JW, Bronson KF. Managing Crop Residue with Green Manure, Urea, and Tillage in a Rice-Wheat Rotation. Soil Science Society of America Journal. 2001; 65.

5. Azraf-ul-Haq A, Imran Q, Naeem M. Effect of integrated use of organic and inorganic fertilizers on fodder yield of sorghum (Sorghum bicolor L. Pakistan Journal of plant Science. 2007; 27: 322–9.

6. CSA. Statistical bulliten for crop production forecast sample survey. CSA. Addis Ababa, Ethiopia; 2008.

7. ATA. Agricultural Transformation Agency (ATA. Addis Ababa, Ethiopia. 2013.

8. CIMMYT and EARO. Enhancing the Contribution of Maize to Food Security in Ethiopia. In: Proceedings of the Second National Maize Workshop of Ethiopia 12-16 November 2001 Addis Ababa. Ethiopia: CIMMYT. 2001.

9. EARO. Research Strategy for Maize. Ethiopian Agricultural Research Organization (EARO. Ethiopia: Addis Ababa. 2000.

10. FAO. Food and Agriculture Organization of the United Nations (FAO) Report, 2008. Rome, Italy. 2008.

11. Fearnside PM. Deforestation in Brazilian Amazonia: history, rates, and consequences. Conservation Biology. 2005; 19: 680–8.

12. Giardina CP, Sanford RL, Døckersmith IC. Changes in soil phosphorus and nitrogen during slash-and-burn clearing of a dry tropical forest. Soil Science Society of America Journal. 2020; 64: 399-405.

13. Lindqvist AK. Managing Land: A Practical guidebook for developing agents in Ethiopia. Technical Handbook. 2005.

14. Legesse W, Mosisa W, Berhanu T, Girume A, Wende A, Solomon A, et al. Genetic Improvement of Maize for Mid-Altitude and Low land sub-Humid Agro-Ecologies of Ethiopia. In: W., Prasanna BM, editors. Meeting the Challenges of Global Climate Change and Food Security through Innovative Maize Research Proceedings of the 3rd National Maize workshop of Ethiopia. Ethiopia: Addis Ababa. 2011; 18-20.

15. Getachew M, Belete K. Yield Related Traits and Yield of Maize (Zea Mays L.) as affected by Green Manuring and Nitrogen Levels at Mizan Teferi, South-west Ethiopia. International Journal of Agronomy and Plant Production. 2013; 4: 1462–73.

16. Negassa W, Negisho K, Yohannes T. Bone meal and rock phosphate as alternative sources of P fertilizer for maize production. In: Amede T, Zewide E, editors. Challenges of Land Degradation to Agriculture in Ethiopia Proceedings of the 6th Ethiopian Society of Soil Science Conference. Ethiopia: Addis Ababa; 2004; 51–8.

17. NFIA. Background information for the development of a national Fertilizer Policy and Strategy in Ethiopia, Fertilizer Industry Agency. Ethiopia: Addis Ababa. 1993.

18. Okalebo JR, Palm CA, Lekasi JK, Nandwa SM, Othieno CO, Waiga M, et al. Use of organic and inorganic resources to increase maize yield some Kenyan Soils: A five year experience. In: Bationo A, Swift MJ, editors. Proceeding of 8th meeting of African Network of Tropical (AfNET) of soil Biology and Fertility Research. Nairobi, Kenya. 2003.

19. Pilbeam CJ, Wood M, Mugane PG. Nitrogen use in maize-grain legume cropping systems in semi-arid Kenya. Biol Fert soils. 1995; 20: 57–62.

20. Sanchew PA, Jam BA. Soil fertility replenishment takes off in East and Southern Africa. In: Vanlauwe B, Diels JS, Merckx N, editors. Integrated plant nutrient management in Sub-Saharan Africa: From concept to Practice. Wallingford, UK: CABI. 2000; 23–45.

21. Singh BR, Goma HC. Long term soil fertility management, Experiments in Eastern Africa. In: Lal R, Stewart BA, editors. Soil Management, Experimental Basis for Sustainability and Environmental Quality. 1995; 347–79.

22. Shalini Misra RKM, Dhyani D. Agriculture Uttarakhand: Issues and management prospects for economic development. Sati MC, Sati SP, editors. Uttaranchal Statahood: Dimensions for development. Indus Publishing Co. 2008.

23. Workayehu T. Effect of coffee residue and cropping system on crop yield and physico-chemical properties of the soil in southern Ethiopia. 2006.

24. Bogale T, Alemu K, Fite T, Hailu G. Integration of Soybean for Crop Rotation in Maize-Based Farming System. 12th Crop science society of. Ethiopia, CSSE: Addis Ababa. 2009.

25. Duftu TB, Assenga RH, Mmbaga AT, Friesen DK, Kikafunda J, Ransom JK. Legume fallows for maize-based systems in Eastern Africa: Contribution of legumes to enhanced maize productivity and reduced nitrogen requirements. In: Friesen DK, Palmer FAE, editors. Integrated approach to higher maize productivity in the new millennium: Proceeding of the 7th Eastern Southern Africa Regional Maize Conference and Symposium on Low-Nitrogen & Drought Tolerance in Maize Conference held in Nairobi. Kenya: CIMMYT/ Kenya. 2004; 325–9.

26. Abera T, Feyisa D, Yusuf H, Nikus O, Al-Tawaha AR. Grain yield of maize as affected by biogas slurry and N-P fertilizer rate at Bako, Western Oromia, Ethiopia. Bioscience Research. 2005; 2: 31–7.

27. Debele T. Effects of organic and inorganic fertilizers on maize grain yield in western Ethiopia. In: Proceeding of the African Crop Science, Conference. Casablanca, Mali. 1999; 229–102.

28. Debele T, Dk F. Effect of enriching farmyard manure with mineral fertilizers on grain yield of maize at Bako, western Ethiopia. In: Seventh Eastern and Southern Africa Regional Maize Conference. 2001; 335–7.

29. Bogale DT, Negassa W, Workayahu T, Liben M, Mesfin T, et al. A Review of fertilizer management on maize in Ethiopia. In: Mandefri Nigussie DT, ST wumasi-Afriya, editors. Enhancing the contribution of maize to food security in Ethiopia: Proceedings of the second national maize workshop of Ethiopia. Ethiopia: Addis Ababa. 2002; 46–55.

30. Thorne PJ, Thornton PK, Kruska PL, Reynolds L, Waddington SR, Rutherford AS, et al. Maize as food feed and fertilizer in intensifying Crop-livestock systems in East and southern Africa: An ex-ante impact assessment of technology intervention to improve smallholder welfare. Nairobi, Kenya: ILRI. 2002; 13–9.

31. Vanlauwe B, Diels J, Sangingal N, Merckx R. Long-term integrated soil fertility management in South-western Nigeria: Crop performance and impact on the soil fertility status. Plant and Soil. 2005; 273: 337–54.

32. Negassa W, Getaneh F, Deressa A, Dinsa B. Integrated Use of Organic and Inorganic Fertilizers for Maize Production In: Utilization of Diversity in land use systems: Sustainale and organic approaches to meet human needs. Conference Tropentag. 2007; 12.

33. Negassa W, Gebrekidan H, Friesen DK. Integrated Uses of Farmyard Manure and NP fertilizer for maize on farmers' fields. Journal of Agriculture and Rural Development in Tropics and Sub tropics. 2005; 106: 131–41.

34. Negassa W, Negisho K, Friesen DK, Ransom J, Yadessa A. Determination of optimum Farmyard manure and NP fertilizers for maize on farmers' fields. In: Friesen DK, Palmer AFE, editors. Integrated Approaches to higher maize productivity in the new millennium: Proceedings of the Seventh Eastern and Southern African Regional Maize Conference, 5-11 February 2001. Nairobi, Kenya: CIMMYT (International Maize and Wheat Improvement Center) and KARI (Kenya Agricultural Research Institute. 2004; 387–93.

35. Zaman-Allah M, Sifi B, L'Taief B, El-Aouni MH, Drevon JJ. Rhizobial inoculation and P fertilization response in common bean (Phaseolus vulgaris) under glasshouse and field conditions. Experimental Agriculture. 2007; 43: 67–77.

36. Bekeko Z. Effect of enriched farmyard manure and inorganic fertilizers on grain yield and harvest index of hybrid maize (BH-140) at Chiro, eastern Ethiopia. African Journal of Agricultural Research. 2013; 9: 663–9.