Review Article

Improvements of Crop Production Through Integrated Soil Fertility Management in Ethiopia

ABSTRACT

Agriculture plays a central role in the Ethiopian economy. In our country, about 85% of total population depends on agriculture and its products. This means agriculture contributes a large share of national product growth. In spite of the importance of this sector, production and productivity are constrained by different biophysical and socio-economic factors. Soil fertility management is one of the core problems that decline Ethiopian agriculture and leads poverty and starvation. The causes of these rooted problems are the land degradation exhibited in form of soil fertility loss, as initiated by different factors as deforestation, overgrazing and with a result of soil erosion, sedimentation, pollution, etc. Hence, the core objectives of this review are to assess the status of soil fertility in the country, the causes of soil fertility loss and find better solutions to soil fertility decline. As the physiological factors of the country are rugged with varying types of soils, particularly the highland where about 90% of the arable land is concentrated, problems such as soil erosion, poor and continuous cultivation are the major causes of soil fertility decline. Therefore, the use of integrated soil fertility management strategy with inclusion and combination of manure, compost, crop rotation, soil conservation practices such as minimum tillage, tied-ridging, residue management, and other practices together with chemical fertilizer and improved crop varieties gives the improved production and keeps the soil fertility status to

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improved level. The practice ~~is~~ undertaken by the government, ~~which~~ is the use of fertilizers in blanket recommendation is not successful as a result of agro-climate, soil and the socio-economic condition of the farmer, resorting to sustainable integrated soil fertility management to get maximum yield without compromising the soil fertility status in the future, this is wise and needed to be followed.

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Key terms: Soil fertility, Soil fertility Factors, Integrated Nutrient Management practices, and Crop Production

INTRODUCTION

Ethiopia, as one of the countries found in the region, shares the broad characteristics of agriculture in the Sub Saharan African ~~region~~. Agriculture is the most important sector in Ethiopia, and it is the backbone of the Ethiopian economy. It accounting for 46% of its GDP and 90% of its export earnings [1, 2, 3]. However, in general the main issue in Sub Saharan African agriculture, particularly in Ethiopia, is soil fertility decline. In Ethiopia, ~~a large~~ population is hardly satisfied by reliable production, instead a decline in their crop yield is letting them suffer from poverty and malnutrition. Studies indicated that in some parts of Ethiopia farmers suffer from lack of what to eat particularly in months starting from June up to September [4]. Actually, farmers in most parts of the country work hard, in seasons of the year when the rainfall is favorable for their cropping; regardless of their effort. T~~t~~hey get ~~very~~ little, which does not help them escape their subsistence way of living.

The blunder with this agricultural problem is very intricate in nature, the complexity arises from various condition of the country such as the agro-climate, topography of the lands, the soil types and socio-economic status of the farming community and the combination of these; the overall effect of which is finally reflected by soil fertility decline and reduction in yield of crops.

In the expansion process of agriculture, farmers deforest the existing forest lands and bring a new form of land use and on their agricultural land, they almost take no organic matter management. Besides, livestock productions on unprotected land lead to overgrazing process and bare the land of grasses, which directs the land to be liable to further degradation through erosion. ~~Hence a~~All these problems cause a loss in soil fertility of the country; on average Ethiopia losses about 42 ton/ha/year soil [5]. With this amount of topsoil, a number of plant nutrients including organic matter are removed. ~~; O~~Over the years the remaining subsoil, soil leftover from erosion, is difficult to work and generally unproductive [5]. This loss of soil fertility is further aggravated by continuous cultivation, which leads to nutrient mining of the soils.

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As the population increases the farming system such as the shifting cultivation and fallowing, which use to be practiced by farmers is now days discontinued to continuously feed a large number of family. Even if farmers have indigenous knowledge how to manage their farms, but the resource they possess limit them not to do the managements such as organic matter management by leaving the crop residue on the field and also to apply the cow dung or manure to their field [6,7].

There are a number of researches done by different stakeholders to address the problems of soil fertility, but most of these concentrate on the application of different types of inorganic fertilizers and pesticides for which the farmer is very far away to pay for them. Irrespective of the different local research studies in Ethiopia until now the fertilizer application undertaken by farmers is based on a national level forwarded by the government. It is based on some general soil studies, for immediate solution of production problems of the country; and this national fertilizer recommendation is known as the blanket recommendation, but it is now found to be an antiquated practice that cannot address the existing condition of the farmers. If scholars have to do a research to address the problems of the farming community, it should be in collaboration/participation with of the farmer himself, in the manner that he/she is able to analyze the problem and understand the solutions given on his farm by interpreting to his own standard.

It is investigated that the farmer's practices and perceptions/knowledge's are very valuable, for example, farmers realized in some parts of Ethiopia that the fertilizer application to give a better yield for cereal cultivation the cereal should follow a rotation of some kind of legume crop and this is found to be true to crops like teff and wheat. Therefore, combining the different farming systems and agronomic practices can help to address the problems of soil fertility decline. Instead of concentrating on mineral fertilizers alone, integrating the different practices which are acceptable and minimizing the expenditure of those poor farmers, like agroforestry, or green manure such as *Erythrinabruice*, crop rotations, intercropping and soil conservation practices, in combination with the application of mineral fertilizer and use of improved crop varieties, is helpful. Consequently, this review focuses mainly on the assessment of the status of soil fertility and the causes of fertility loss and to finds better solutions to soil fertility problems in the country. Therefore, the objective of this paper is to review improvements of crop production through integrated soil fertility management in Ethiopia.

The Soil Fertility Status in Ethiopia

In the different regions of Ethiopia there exist various topographic, climatic or agro-climatic and soil conditions [7]. These varying conditions together with the socio-economic status of the society creates various factors that cause soil fertility loss with varying degrees. Therefore, the soil fertility status of Ethiopia cannot simply be generalized, because there are different local soil fertility statuses that may range from fertile soil to highly infertile soil [8].

But in general, the soils of most Sub-Saharan Africa particularly the east African soil are generalized as infertile with “Orthodoxy”, Orthodoxy is to mean that infertility of the soil in this region is an apparent phenomenon, which does not need any proof. Or in the original saying “the existence, the extent and causes of soil fertility problem are accepted without question” [9].

Soil fertility and productivity is more than just plant nutrients and can be defined as “the physical, biological, and chemical characteristics of soil, for example, its organic matter content. In line with this, Belay [7] reported that acidity, texture, depth, and water-retention capacity all influence fertility [10, 8]. Because these attributes differ among soils, soils differ in their quality [8]. Similarly, Belay [7] reported that some soils, because of their texture or depth, for example, are inherently productive because they can store and make available large amounts of water and nutrients to plants [10]. Equally, other soils have such poor nutrient and organic matter content that they are virtually infertile.

Even if the soil fertility status of Ethiopia is not documented well, its low fertility status can be exhibited, by some of the macronutrient, and organic matter, CEC (that means…) and, pH levels of the different areas. As already stated earlier the soil fertility status in Ethiopia various among the different condition, for example, the variation in the agro-ecological zones and variations within plots in a farm is indicated in (Table 1) [11]. Fertility status also can vary between contrasting fields that are within the same soil types, for example, soils around the homestead are relatively fertile, in comparation with to soils that are far away from homestead (outfields) [12].

To strengthen the above explanation, we can take a study made at Ethiopian highlands, which indicates that there is variation in fertility status of soils between homestead and outfield areas in Enset (*Enseteventricosom*) growing. The result suggests that the variation in soil fertility is not only due to nutrient deficiency (unavailability), but it is also due to the existence or absence of soil organic matter [13] (Table 2).

In the four-year study (2001-2004) on Enset (*Enseteventricosom*) on farmers field, where farmers are grouped as resource-rich (G1) and resource-poor (G3), based on their capability of allocation of resources to their agricultural enterprise, there is an observed variation in soils among groups and type of farms [7]. In the study, the yield components and nutrient contents of the Enset are compared for the homestead and outfield plantations [7]. Hence, according to Belay [7] reported that it is found that the homestead soil have significantly higher contents of macronutrients such as N, P, K and Ca, but the Enset plant took up 150% greater amounts of the macronutrients for the outfields than the homestead. H, however, the yield components of the Enset declined by 90% for height and reduced by 50% for pseudo-stem diameter in outfield farm relative to the homestead [13].

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The decline in the yield components is a reflection of the fewer amounts of organic matter in the outfield, which resulted in low water holding and retention capacity of the soil, with the consequence of decline in the yield components of Enset due to moisture stress, rather than nutrient stress [13]. Whatever it is, the outfield soils are infertile or have lost its fertility in terms of its organic matter content relatively. Even if the Enset plant absorbed approximately adequate amounts of the nutrient, however, there occurred a yield decline as observed on its yield components [7]. Here we can see that the fertility status of the soil in the farmers' own field is lower due to less organic matter content of soil, which resulted in moisture stress of the soils [13].

The spreading problem in Ethiopia, an investigation made by MARC (2007) as cited by Zelleke *et al.*, [14] indicates that soils of the different areas can be rated as low concerning their organic matter and total nitrogen content (Table 3). For soil to be productive, it needs to have organic carbon content in range of 1.8-3.0% to achieve a good soil structural condition and structural stability [15]. In the same document it is tabulated that soil with organic carbon of 1% and less is considered as low to extremely low. The nitrogen rating of soil is also indicated as high when its soil concentration is in the range of 0.25-0.5% but can be considered as low below these values [16, 3]. Therefore, we can see that both the amount of organic carbon and nitrogen in most areas of the country is low to be suitable for better crop production.

On the other hand, a study made at Southeast Ethiopia, on soil fertility status based on farmers' fertility naming indicates that soil samples taken at different depths and analyzed using standard laboratory procedures have shown the difference in fertility status. Farmers' fertility naming goes in conformity with the laboratory analysis, even if farmers use qualitative methods to class the fertility status of the soils [9]. The clay content of the soil increases down the depth, but the pH, organic matter content, and total nitrogen decrease down the soil depth. However, on rating the soil fertility status based on the laboratory analysis, using parameters such as organic carbon (OC%), Cation exchange capacity (CEC), pH and some nutrients, can be observed indicate, that the soil of the southeast is low to medium in its organic carbon content, low to medium in total nitrogen, lower to medium in CEC and adequate in pH [9]. Based on the results we can generalize that the fertility status of the southeast soils is low to medium infertility, but not fertile or very fertile.

Major Cause of Soil Fertility Loss in Ethiopia

A few decades ago, most soils of Ethiopia were covered by vegetation and the fertility of the soil was better off, for example in the 1960-1970s. But with an increasing population, the pressure on lands escalated, through deforestation, overgrazing and continuous cropping with the this following system discontinued. Hence most soils lost their fertility, in terms of the physical property, and chemical properties, such as macronutrient, micronutrient and organic matter depletions [17, 7].

For all the fertility losses there are various causes in the different regions of the country, in totality, the major causes of soil fertility decline isare land degradation, which is caused by the different agents such as soil erosion, deforestation, overgrazing, sedimentation, continuous farming, and pollution [7]. The major causes of soil erosion and sedimentation are not only high intensities of rainfall and floods, but the problem is much aggravated by deforestation and overgrazing, in the absence of the two, soil erosion and sedimentation will remain to the minimum [4, 7].

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According to Abera [4] has been explained the major cause for soil fertility decline but for convenience of this review we concentrated on two issues: the soil erosion and continuous cultivation as major causes of soil fertility decline; because the other causes are the contributors for the two major causes ~~soil erosion and continuous cultivation in relation to soil fertility decline~~. In most parts of Africa particularly east Africa, the major causes of soil fertility decline are soil erosion, poor organic matter management, continuous cultivation, etc. In the study made in Kenya, the causes of soil fertility decline are given different scores and then ranked to screen out the major cause and it is found that erosion is the first major cause of the problem [18].

Soil Erosion: Soil erosion is described as the process of loss of nutrient-rich clay and organic matter because thein raindrop splash, impoverishing the upper topsoil, and while subsequent erosion peels off the upper soil layers [19, 7]. In Ethiopia due to the surface topographic condition of most arable lands that concentrate in the highland, the problem of soil erosion is a serious one. In this condition Ethiopia losses of topsoil are about 137 tons/ha/year, when this amount of soil is estimated in terms of soil depth it is about 10 mm. Correspondingly, Belay [7] reported that the rate of topsoil loss is very high in Ethiopia compared to the rate of topsoil formation, under agricultural condition, in general, the soil loss is about 10 mm/ha/year, and formation of this depth of soils takes place in about 200 years [20, 7].

Vegetation cover determines the extent of soil erosion in Ethiopia, because of the rugged topography of Ethiopia, hence agricultural fields are most susceptible to erosion effects as they are practiced on slopping lands. M~~; m~~oreover under semi-arid conditions, there is normally sparse ground cover at the onset of rains, leading to relatively severe rates of runoff and soil loss [21, 7]. Under the Ethiopian condition, we can see that croplands are more vulnerable to erosion and soil loss (Table 3).

When the topsoil is removed by erosion, the clay content of the remaining soil increases, but the organic matter content decreases, which is an indication of unfavorable conditions and loss of soil fertility. The study made at different times on Vertisols of Ethiopia indicates the loss of topsoil results in high clay content, because as soil depth increases the clay content of the Vertisols soil increase [23]. The loss of topsoil results in loss of different soil nutrients, for example, the ~~macronutrient~~ nitrogen, with a consequence of yield losses. A study in South and East Africa on two cereal crop ~~M~~maize and w~~W~~heat, indicated~~s~~ that there is ~~a significant~~ loss of crop yield for these crops due to loss of nitrogen from the soil in the (Table 4) [24, 3].

There are different types of soil erosions, ~~wind erosion, water erosion, etc,~~ but water erosion is one of the major causes of soil fertility problems in Ethiopia. It is estimated that the national soil removal by water erosion is about 1493 million tons per annum, however, the magnitude varies among individual fields and the maximum removal may go as high as 300 tons/ha/year. The same study on cropland estimate indicates that the average soil loss rate goes to

Formatted: Indent: First line: 0.39" about 42 ton/ha/year, which is about 4 mm in terms of soil depth removed [25]. It is estimated also that the rate of soil removal calculated in the cropland, is able to wear away the whole profile in about 100-150 years, provided that the depth of soil profile is kept to 60 cm [25, 7]. Besides, the study made at Digil micro-catchment Ethiopia, the soil erosion is high enough to form rills and the total amount of rill formed is shown in (Table 5).

Table 1. Soil fertility status variation between agro-ecological zones and between plots within a farm~~.~~

Agro-ecological zone	Status of the soil fertility metrics		
	~~P^h~~**pH**	Organic carbon~~C~~ (g kg^{-1})	Total nitrogen~~N~~ (g kg^{-1})
Equatorial savanna	5.3	24.5	1.6
Guinea savanna	5.7	11.7	1.4
Sudan savanna	6.8	3.3	0.5
A field within a farm	?	?	?
Home garden	6.7 – 8.3	11 – 22	0.9 – 1.8
Village field	5.7 – 7.0	0.5 – 0.9	0.5 – 0.9
Bush field	5.7 – 6.2	0.2 – 0.5	0.2 – 0.5

Source: (Sanginga and Woomer[11])

Table 2. Variation in soil fertility between contrasting fields of the same soil type (Nitisol, west shewa)

Soil type	~~Ph~~pH	N (%)	P (%)	K	Ca	Ma	CEC
				meq/100 g soil			

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Field near to home	5.50	0.24	17.93	2.20	12.76	2.63	29.80
Field far from home	4.60	0.16	8.40	1.41	8.95	1.76	19.51

Source: (Getachew and chilit[12])

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Table 3. Estimated rates of soil loss in Ethiopia for different land use and vegetation classes

Land cover type from LUPRD	Area (%)	Estimated soil loss (~~103~~ kg/ha/yr)	Estimated soil loss (~~103~~ kg/ha/yr)
Crop land	13.1	48	672
Perrennial crop	1.7	8	17
Grazing and browsing land	51.0	5	312
Currently unproductive	3.8	70	325
Currently uncultivable	18.7	5	114
Forest	3.6	1	4
Wood and brushland	8.1	5	49
Total	100.0	136	1493

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Source: (Hurni[22]), LUPRD: Land Use Planning and Regulatory Departments

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Table 4. Calculated loss in grain yield due to losses in Nitrogen through erosion

Crop	Yield loss (kg/kg N) lost	Range of nutrient loss N(kg/ha)		Range of nutrient loss N (kg/ha)	
	Crop response ratio	Low	High	Low	High
Maize	?	36	429	0.345	4.12
Wheat	?	36	429	0.248	2.96

Source: (Sertsu[24]).

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Table 5. Total length and volume of rills and damaged area

Rill parameters	Measured quantities

Length of rill (m)	861.00
Volume (m^3)	98.50
Damaged area (m^2	432.70
Damaged area out of the total area (%)	1.02

Source: (Belay[7])

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Remedial Solution is given to Reclaim Soil Fertility

As a solution to soil fertility problem the Ethiopian government, in a ~~as a~~ first moment, ~~try to solve the problem in a national level,~~ have forwarded~~,~~ fertilizer recommendation for the two major macronutrients, ~~the~~ nitrogen and phosphorus, at a rate of 100 and 50 kg/ha in the form of ~~Urea~~ urea and DAP (~~Di~~ di ammonium p~~P~~hosphate), respectively [26]. However, this recommendation is unable to solve the problem as expected because the soil under each agro-ecologic condition is variable or even the soil conditions in a single farm is variable, so managing such condition under the blanket recommendation is not valuable [7]. Above all the farmer cannot afford this blankets recommendation hence about 87% of farmers apply lesser fertilizer, rate of 50 kg/ha u~~U~~rea totally, leaving the DAP [26]. ~~Besides~~ Actually, ~~still,~~ the Government is making an effort to have agroecology-based fertilizer recommendations for some of the major nutrients limiting crop production [14].

There are also many efforts in the form of researches and various projects to improve the livelihood of the smallholder farming community to reverse the fertility of the soil and increase productivity per unit land. This is being undertaken by governmental and non-governmental organizations; here we want to comment that the results from the best researches and projects should be included in the Agriculture policy of the country to come to affect.

The role of Integrated Soil Fertility Management

Integrated soil fertility management refers to a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs, and improved crop varieties combined with the knowledge [27] on how to adapt these practices to local conditions. A~~, a~~iming at maximizing agronomic, the use efficiency of the applied nutrients and improving crop productivity.

In Ethiopia, it is a well-known fact that fertilizer recommendation is based on a national level, forwarded by the government, which is known as the blanket recommendation. This recommendation does not consider the local condition, regardless of the various researches done under different ~~local~~ conditions, hence it remained partially unsuccessful and it is thought by farmers that increasing yield through fertilizer application is very difficult and unachievable by their capacity [26, 7]. That is because the green revolution thought by the government of Ethiopia incurs the farmer into high costs of fertilizers and pesticides, even if a credit facility is provided to the farmer, he/she cannot afford the cost as the yield obtained is not balancing it well. Moreover, the recommendation doesn't consider the farmer's local condition.

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Hence the principle of green revolution in Ethiopia under the blanket recommendation is not successful under most conditions. T~~, t~~hen, more researches have to be done under farmers condition with his own participation in such a manner that the research is able to minimize the different sorts of local problems, by reducing the soil fertility loss and decline in productivity, under what is called the integrated soil fertility management [26].

The Main Goal of Integrated Nutrient Management

Sustainable agricultural production incorporates the idea that natural resources should be used to generate increased output and incomes, especially for low-income groups, without depleting the natural resource base [28]. In this context, it maintains soils as storehouses of plant

~~nutrients~~ elements that are essential for vegetative growth. Its goal is to integrate the use of all-natural and man-made sources of plant nutrients, so that crop productivity increases in an efficient and environmentally benign manner, without sacrificing soil productivity of future generations. It relies on a number of factors, including appropriate nutrient application and conservation and the transfer of knowledge about its practices to farmers and researchers.

Application ways of integrated soil fertility management

Integrated Nutrient Management should be applied in ~~a~~ manner that all sorts of soil fertility losses are minimized, such as soil erosion, and nutrient mining from the soil and causes that result in these two major problems. IFDC (International Fertilizer Development Center)-Africa promotes ISFM (Integrated Soil Fertility Management) through a participatory and process-oriented approach that builds on a solid understanding of local settings, indigenous knowledge, and scientific expertise, and targets at different spatial and temporal scales, both technological and institutional change. The complexity of farmer reality requires much emphasis on farmer experimentation and participatory learning, and building of partnerships between soil fertility management stakeholders (farmers, credit providers, input dealers, research and extension agencies, government) from village to the district to national level [29, 7].

In a research done at Gonuno, in wolayita, in participatory approach with farmers it is identified that the following steps as part of integrated nutrient management can be applied to keep the soil fertile and productive [30, 7]; i) implement physical and biological measures to minimize soil loss caused by water erosion; ii) analysis of the soil to identify the limiting soil-related factor (nutrients, pH and alike); iii) increase soil organic matter content by incorporating crop residues and manure into the soil and growing legume cover crops; iv) improve the water holding capacity of the soil by contour plowing, minimum tillage and adding organic matter, and

v) increase soil nutrient levels with applications of mineral and organic fertilizers [3], and by growing N-fixing legumes and vi) use crop rotation, intercropping and relay cropping schemes to minimize losses and enhance fertility, with combinations of deep and shallow rooted crops, and by growing soil enriching species with those that deplete the soil [7].

Role of Integrated Soil Fertility Management in yield of crops

Many research ~~findings~~ have shown that neither inorganic fertilizers nor organic sources alone, can result in sustainable productivity [31, 32, 43, 42]. Moreover, the value of inorganic fertilizers is increasing and becoming too expensive for resource-poor smallholder farmers. Accordingly, Geremew [3] reported that the best remedy for soil fertility management is ~~, therefore,~~ a combination of both inorganic and organic fertilizers, where the inorganic fertilizer provides nutrients and the organic fertilizer, mainly, increases ~~soil~~ organic matter and improves soil structure and buffering capacity of ~~the soil~~ [32,42,3]. The combined application of inorganic and organic fertilizers, usually termed integrated nutrient management, is widely recognized as a way of increasing yield and/or improving the productivity of the soil sustainably [33].

In Ethiopian, particularly in the highlands condition, integrated soil fertility management can give better yields as high as a balanced application of fertilizer and significantly higher yields than the traditional cultivation Belay [7] and method other than the integrated methods. For instance, in Benishangul Gumuz region research done on woredas, Agalometi and Sirba indicate that a combination of few agronomic management practices like tillage (not local type), application of manure and compost, resulted in higher yields of different varieties of maize [34].

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In the study plowing alone ~~significantly~~ ($P< 0.05$) improved the average maize yield in 2002 from 7.9 to 9.5 tons/ha. Correspondingly, plowing and adding either manure or compost also resulted in a significantly higher yield in 2002 (10.1 and 10.0 tons/ha, P<0.05). However, there was no significant difference among the three best treatments [34]. According to Belay [7] reported that in Nitisols, of South Ethiopia, a study by the Hawassa Agricultural Research center indicated that using *Erythrina bruice* as a green manure crop either its biomass alone or in combination with mineral fertilizer, is found to increase the yield and yield components of bread wheat [35, 7]. And also [7]reported that *E. bruice* is a nitrogen-fixing plant, which fixes the nitrogen through its leaves; this tree is endemic to Ethiopia (Belay [7]), and is a fast-growing and nutrient-rich plant, particularly high with nutrient contents ason the NPK [35].

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Combined data analysis of the two seasons revealed that there was a highly significant (P =0.0001) difference among treatments in their effect on grain yield of maize [35]. In the same way, Geremew [3] reported that the application of 5 and 10 tons/ha of *E. bruicie* biomass significantly increased the grain yield of wheat by 82 and 127% over the control, respectively. Similarly, tThe application of the recommended dose of NP fertilizer ($N46P_40$) has significantly increased the grain yield by 145% over the control. There was no statistically significant difference between plots that received the sole application of *E. bruci* biomass at 10 tons/ha and recommended dose of fertilizers. Yet, the highest grain yield was obtained from plots that received combined application of *E. bruicebruci* biomass + inorganic fertilizer applied at 10 tons/ha + $N23P_20_5$ tons/ha + $N46P_40$ and 10 tons/ha + $N46P_40$. These treatments increased the grain yield of wheat by 173, 190 and 227% over the control, respectively [35].

Comment [H14]: Wheat, E. bruice or maize? So confused!!

It is a well-known fact that use of green manure increases the yield of crops, though it is not practical by most farmers, for most reasons that most trees provided for this purpose are exotic, and the trees are slow-growing, and research attention is not given in this area [35]. In agreement with this, Geremew [3] reported that, regardless being a fast-growing tree reaching up to 6 m height within 3 months, *E. bruicebruci* has a very important agroforestry attributes such as, spreading leaves, source of large quantities of swiftly decomposable litters, vigorous re-growth, copious coppicing as well as rapid recovery after a spell of prolonged drought [36, 37].

The farm yard manure in Western Hararghe, which is situated in Eastern Ethiopia, but it is also investigated that the major problem for the decline in crop productivity is the decline in soil fertility [38, 7]. Consistent with Gremew [3] reported that since to recover the soil to its productive state it is not enough to apply mineral fertilizer alone, therefore, integrated nutrient management is the best measure for increasing crop production. Based on thise factors, a study were realized and concluded that, a combination of 4 tons/ha FYM +75 kg N/ha with 60 kg P/ha performed best among others, with maize yield of 8.16 tons/ha. Based on the study a combination of 4 tons/ha FYM+75 kg N/ha with 60 kg P/ha performed best among others, with maize yield of 8.16 tons/ha. It is indicated also that the application of 10 tons/ha FYM alone can give as equal yield as 100 and 100 kg P/ha together [38]. In the area there are a number of districts such as Chiro, Doba, Tullo, Mesela, Gemechis, Kuni, Boke Habro and Daro Labu, where soil productivity is severely constrained by poor soil fertility and poor crop management practices. It was observed that, in this case, Therefore, yield is too small, usually less than 2 tons/ha, as compared to a potential yield of over 5 tons/ha in the region [39].

Combination with mineral fertilizer is important to increase the in reversing soil fertility, but also the practice of minimum/zero tillage and residue management in combination with mineral fertilizer application is helpful in reversing soil fertility and hence the crop productivity. In a five years study (2000-2004) in western Ethiopia, the use of zero tillage with residue retention on the field (MTRR) is was the better than the st practice as compared to zero tillage with residue removal (MTRV) and the conventional tillage (CT) [40]. In the study, three nitrogen

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N fertilizer rates ~~are~~ were applied in combination with the tillage systems. The principal rate of ~~nitrogen~~ N fertilizer ~~being~~ was 92 kg N/ha and the other two rates ~~are~~ were 25% greater than and 25% less than the principal rate. After two years, was observed ~~Even if in the first two years there is no difference between MTRR and MTRV both of which are significantly~~ higher yield of maize in zero tillage and the conventional tillage ~~than CT, in the next consecutive years the reality is reflected in that the yield of maize in MTRR went superior over the two MTRV and CT, this is due to a gradual build-up of soil fertility~~ [40]. The study reflects that the integration of minimum/zero tillage and residue management, ~~together~~ with mineral fertilizer give~~s~~ ~~an~~ advantage over the conventional fertilizer application.

In some semi-arid regions of Ethiopia where there is a shortage of soil moisture due to shortage of rainfall, the use of tie-ridging at the sowing period and application of mineral fertilizer increased the yield sorghum. Geremew [3] ~~reported that an experiment~~realized an experiment with ~~conducted in the Aberegalle sub-district in Tigray region with split-plot design on~~ different tillage practices and fertilizer applications ~~have main plot treatments of shilshalo (traditional ridge without ties) for broadcasted planting (SBP), tied-ridging at planting (TR0WAP), tied-ridging at four weeks after planting (TR4WAP), zero tillage (ZT), and shilshalo for row planting (SRP)~~ [3]~~. Two fertilizer rates of nitrogen (N) and phosphorus (P), as 0-0 NP /ha (without fertilizer, F1) and 32-10 kg NP /ha (with fertilizer, F2) treatments, are the sub-plots~~ [41]. The result then indicated that tie-ridging in combination with fertilizer application ~~is~~ was the best practice, better than the other tillage practice even with fertilizer applications.

As reported by Belay [7], the experiment conducted for two years (2002-2003) on two local sorghum varieties Woitozira and Chibal (*Sorghum bicolor* L. Moench) showed an increase in yield in range of 7-48% for tie-ridging at planting with fertilizer application relative to the other treatments [41, 3]. The main reason here ~~is~~ was ~~that~~ the moisture conservation capability of the tillage practice ~~since the area is semi-arid tie-ridging starting from planting period is~~was more advantageous than tie-ridging after four weak and ridging without tie making.

CONCLUSION AND SUMMARY

In Ethiopia, the main causes that decline in the fertility of soil are soil erosion, continuous cultivation, and low nutrient application. In some cases, the loss of organic matter together with the loss of topsoil aggravates the problem of soil water retention resulting in moisture stress ~~rather than~~and nutrient deficiency. Due to the high cost of fertilizer, most of the farmers in the country use less amount with blanket recommendation, this becomes complex for management due to intricate combinations of agroecology, the edaphic factors, land topographies, and the socio-economic condition of various locations. Therefore, the blanket recommendation and other fertilizer and pesticide application alone in Ethiopia are not a sufficient solution to the existing problem in the face of the farmer and in the face of reality. The solution should be the one which considers the complex interactions of agro-climate, soil, topographic and the environmental condition of the locality.

Comment [H17]: Confused.

Integrated soil fertility management is the core option to resolve the occurred soil nutrient problem in ~~our country~~Ethiopia. It is vital to examine the complex interactions and effects of the agroecology, edaphic factors, and the environment with the different agronomic practices. Once the interactions and effects are understood, it will be advisable to insert agronomic practices and important inputs that are efficient to the local condition. As the knowledge of the interaction and other technologies increases the efficiency of the agronomic practice will also increase and finally increasing the yield of the crop. Moreover, agronomists that intend to do research should focus on the participatory research approach ~~on farmer's~~ field, which is also important to solve the problem that we face. This includes soil conservation practice like conservation tillage, different cropping systems, and organic matter application needs to be implemented together with integration of other sustainable practices. Hence, it is better to proceed our way towards the sustainable system of crop and other productions, through the integrated soil fertility management. ~~The current paper reviewed different soil fertility management practices that advance soil fertility for improved crop production.~~

FUTURE PERSPECTIVE

Ethiopia is a tropical country that has a multi agro-ecological zone and landforms. ~~, and i~~It's economy and food security ~~mainly~~ depend ~~on~~, mainly, on agriculture and agricultural products. In the different region of Ethiopia, there are various topographic, climatic or agro-climatic and soil conditions, and these varying conditions together with socio-economic status, ~~of the society~~ create various causes for soil fertility loss with varying degrees. This loss of soil fertility is further aggravated by continuous cultivation, which leads to nutrient mining of the soils.

As the population growths the farming system such as the shifting cultivation and fallowing, which use to be practiced by farmers is now days discontinued to continuously feed a large number of family. So, for the next times governments should be given attention to the adoption of farmers accept new technology on soil management practice. In general, cultural sectors, researchers, governments and students, should have responsibility to manage soil fertility and reduce its losses by giving awareness to farmers to used integrated soil fertility management and adoption of new coming technology.

Comment [H18]: Confused.

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