Integrated Soil Fertility Management Option for Enhancing Wheat Productivity in Ethiopia: Review

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Abstract: Soil nutrient depletion is considered to be the root cause of declining crop production and productivity and thus causes unsustainable balance between agriculture and ecosystem. Integrated soil fertility management with the use of different inorganic and organic sources has been carried out to alleviate the problem in different parts of the country. Therefore, the objective of this paper was to review effect of integrated nutrient application in improving productivity of wheat crops in Ethiopian context. Combined use of inorganic and organic fertilizer gave better wheat productivity. Maintenance of nutrient stock at the economically optimal level with appropriate methods of soil management is essential for sustainable wheat production and productivity. Grain yield of wheat was significantly increased following different rates of organic and inorganic fertilizer. The integrated use of manure along with mineral fertilizer also found improved important soil properties and wheat production per area. The use of integrated soil fertility management approach with inclusion and combination of chemical fertilizer, organic input and using improved crop varieties gives better wheat production. Generally, combined use of properly managed manures or other organic source and low rates N or P fertilizers could be used for wheat production in the country.

Key words: Chemical Fertilizer · Organic Source · Soil Nutrient Management · Wheat Productivity

INTRODUCTION

Reduction of soil organic matter and loss of nutrients are among the major constraints to agricultural productivity in tropics as a results of soil fertility depletion [1, 2]. Most of the Ethiopian high land soils are infertile so that cannot support sustainable yield without addition of fertilizer sources. Moreover, continuous cropping and inadequate replacement of nutrients removed in harvested crops or lose through erosion and leaching have been the root causes of soil fertility declines, especially in the intensively cultivated farms in highlands of the country [3]. Soil fertility reduction is one of the leading production constraints particularly in sub-Saharan areas [4]. Soil degradation is the most serious bio-physical constraint limiting crop productivity in Ethiopia [5]. The problem is aggravated in highly populated area of the high lands of the country. Assessment conducted in high land of Ethiopia indicated that the average annual soil depletion from agricultural land is estimated to be 137 ton ha~1 per year, which is approximately an annual soil depth loss of 10 mm [6].

Soil fertility loss is caused by many factors such as entire crop harvest from the field, severe erosion, low soil organic matter content, limited fertilizer input and inappropriate land management [7]. Application of chemical fertilizers did not get attention because there is a broad recognition that soil fertility decline is a major production constraint in the country [8]. In addition, soil acidity that induces phosphorus fixation and aluminum toxicity are the main constraints of Ethiopian high land soils. This is particularly apparent in soils with pH less than 5.5, the effect being attributed mainly to nutrient deficiency and toxicity. In these soils, plants unable to obtain phosphate due to fixation except enough is applied [9]. Soil organic carbon decline is another constraint that diminishes crop production in the country. Amede et al. [10] showed that nutrient availability, soil water content, nutrient cycling and nutrient stock improved by addition of organic materials.

Combining different farming systems and agronomic practice can help address the problems of soil fertility decline instead of concentrating on chemical fertilizer alone, integrating different practices which are acceptable
and minimize the expenditure of poor farmers like green manure, crop rotation, intercropping, compost in combining with mineral fertilizers and improved varieties. Therefore, the Objectives of this paper is to review the role of integrated soil fertility management option for enhancing wheat grain yield in Ethiopia.

**Status of Soils in the Wheat Growing Area of Ethiopia:**
Soil fertility is a quality of a soil to supply nutrients in proper amounts without causing toxicity, whereas soil productivity is the capacity of a soil to produce a specific crop or sequences of crops at a specific management system. Optimum productivity of any cropping system depends on adequate supply of plant nutrients. Continued removals of nutrients with little or no replacement have aggravated the potential for future nutrient related plant stress and yield loss [11]. Soil fertility depletion is the major environmental challenge that affects agricultural production and the livelihoods of farmers in Ethiopia. Soil fertility depletion estimated showed that about 106,000 km² (9.6% of the total area of the country) was not able to sustain crop yield. Stoorvogel et al. [12] estimated that about 41 kg of N, 6 kg of P and 26 kg of K is lost per hectare per year from Ethiopian highlands. On the other hand, about 41% of the total arable land of the country is acidic, of which nearly one-third faces the problem of aluminum toxicity. The direct cost of this soil fertility depletion was estimated to be 3-7% of agricultural GDP [13].

In the Highlands of Ethiopia, Nutrient balance study conducted in different area showed that the high potential areas for agricultural productions are currently exposed to severe nutrient depletion. Studies on nutrient flow in the central highlands of Ethiopia revealed that the nutrient balance in different soil fertility classes varied from -20 to -185 kg N, from +11 to -83 kg P and from +23 to -245 kg K ha⁻¹ yr⁻¹ [14] and the average annual soil loss from agricultural land is estimated to be 137 t ha⁻¹ yr⁻¹, which is approximately an annual soil depth loss of 10 mm [15]. These indicate that major nutrients outflow far exceeds inflows in a range of soil types which results negative nutrient balances. Currently, Gedefä (2018) also indicated that the nutrient depletion of -7 to -10 kg N, 1.5 to -0.1 kg P and -12 to -19 kg K ha⁻¹ yr⁻¹ and were observed under different classes of land units. The results of national soil fertility mapping initiative have also indicated that the mineral nutrient status of most soils in high lands of Ethiopia is low including N, P, K, S, Fe, Zn and B (Ethio-SIS, 2015). Similarly, many soils in Ethiopia are poor in organic matter content [16].

Even though the extent of this problem varies spatially, it depends on variation in geology, relief, ecology, rainfall, land use, soil types and population density [17], the problem is exceptionally severe in the highlands of the country, where 88% of human and 77% of the total livestock population is concentrated [18]. The severity of the problem is partly attributed to topographic and climatic variables [19]. But in Ethiopian highlands there are many factors that contribute to the decline on fertility status of soils from which the major one is land degradation due to deforestation, human and livestock population pressure, continuous cropping and inadequate use of crop residues and little or no use of modern technologies to replenish soil fertility [20].

**Soil Fertility Decline and Wheat Production Constrain in Ethiopia:** Wheat (*Triticum aestivum* L.) is globally one of the most important cereal crops in terms of area and production. Ethiopia is the largest wheat producer in sub-Saharan Africa covering an estimated area of 1.7 million ha and with an annual production of 4.6 million tons [21]. Mean wheat yields increased from 1.3 t ha⁻¹ in 1994 to 2.76 t ha⁻¹ in 2019 which is well below experimental yields of over 5 t. ha⁻¹. Thus, the country was forced to import 30 to 50 percent wheat grain to fill the gap over the past decades [22]. As a result, the current wheat production is inadequate to Ethiopia’s needs due to mainly soil fertility depletion and inappropriate soil management [23]. Soil fertility decline affects crop production in Sub-Saharan Africa including Ethiopia. The nutrient balance conducted in Ethiopia appeared to be negative because nutrient loses are greater than nutrient inputs. Intensive cropping systems, shortened fallow periods, reduced manure applications, extensive use of crop residues for fuel or fodder and removal of ground cover, all lead to soil fertility decline which in turn decreased wheat production. In addition, soils have low fertility due to a low rate of fertilizer use and insufficient organic matter application [24]. Hence, the major constraints to wheat production in Ethiopia could be the decline in soil organic matter, nutrient imbalance, as well as soil acidity. The combined application of organic and inorganic fertilizer is therefore a productive approach to improve soil fertility and to increase wheat productivity in Ethiopia.

The major pathways of soil fertility decline on farmlands include the loss of nutrients through erosion, leaching, volatilization, crop uptake and harvest without the corresponding replenishment. Soil nutrient replenishment is, therefore, a prerequisite for halting soil
fertility decline. This may be accomplished through the application of mineral and organic fertilizers. Moreover, integrate nutrient management has been proposed as an appropriate strategy to ameliorate soil fertility decline and improve productivity of crop [25]. Hence, unless maintaining soil fertility, one cannot talk about increasing yield to feed the alarmingly increasing population and to get optimum, sustained-long lasting and self-sufficient wheat production.

Soil Fertility Management for Increasing Wheat Production: Sustainable crop production needs proper management of soil nutrient and its maintenance. Integrated supplies of nutrients to plants through organic and inorganic sources are becoming an increasingly important aspect of environmentally sound agriculture. According to Assefa [26] soil fertility management practices that include animal manure, crop residues, crop rotation, mineral fertilizer, vermicompost etc help to cope with declining soil fertility, which differ among farmers and among locations. Nutrients contained in organic manure are released slowly and are stored for a longer time in the soil, thereby ensuring a longer residual effect and persistence of nutrient availability [27]. For improvement of soil condition and maintenance of soil health to ensure optimum production, there is a need to reduce the cost of fossil fuel-based inorganic fertilizers, which have significant adverse influences on the environment. The use of organic matter and mineral fertilizers has been proved to be a sound soil amendment strategy.

High yields of wheat can be obtained from highly productive varieties with appropriate nutrient and crop management on fertile soils with adequate water supply. Globally, wheat yields have increased considerably as a result of breeding programmes that have incorporated the short-straw trait from Mexican varieties. Such varieties are more responsive to applied nutrients and are also more resistant to lodging as compared to the local wheat varieties [28]. Wheat can grow on almost any soil, but for good growth it needs a fertile soil with good structure and porous subsoil for deep roots. The low mean national yield for wheat is primarily due to depleted soil fertility, low fertilizer usage and the unavailability of other improved crop management inputs such as improved seeds, diseases and weed control measures and inaccessibility of farmers to finance, farm machinery and training. The major effect of soil fertility decline is the observed reduced food production in most African countries, including Ethiopia. In order to sustain soil and crop productivity, it is necessary to explore alternative soil fertility replenishment strategies, which are effective and affordable to farmers, especially the smallholder farmer.

Organic Fertilizer Amendment: In order to sustain agricultural productivity in the long term, soil organic matter needs to be maintained by continuous addition of organic manures and amendments especially composted materials. The main factors for soil organic matter enrichment are quantity, type and humification degree compost or vermicompost and soil properties such as soil type and clay content [29]. Vermicompost are products derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. It contains enzymes like amylase, lipase, cellulase and which break down organic matter in the soil to release the nutrients and make it available to the plant roots. Vermicomposting also increases the levels of soil enzymes like dehydrogenase, acid and alkaline phosphatases and urease [30]. Vermicomposting is finely divided peat like materials with high water holding capacity, perfect structure, high porosity and aeration and it is an organic fertilizer that is rich in nutrients, poor in readily biodegradable carbon and relatively free of any plant and human pathogens. It has greatly increased surface area, which provides greater area for microbial activity to take place and strong adsorption and retention of nutrients [31, 32]. Vermicomposting as a biological process of composting, in which some species of earth worms are used to enhance the process of waste conversion and produce a better end product. Certain earth worm species suchlike Eisenia foetida commonly used in worldwide for organic waste degradation and are found to be very successful functionaries for compost production from organic wastes. The improvements in growth and yields of crops grown on soils that had been amended with vermicompost could be attributed to several factors as physicochemical characteristics of the soils and improves plant growth and growth parameters. Vermicompost increases the plant growth and yield by providing nutrients in available form and enhance seed germination, growth and yield of crops. Kumar et al. [33] reported that residual effect of vermicompost on wheat production and obtained 4.95 and 39.53 t. ha⁻¹ of grain and straw yield, respectively. Also, Davari et al. [34] indicated that application of organic source fertilizer resulted in a significant increase in all the growth parameters and yield attributes of wheat.
Combination of vermicomposting at 3.8 t ha\(^{-1}\) and poultry manure at 2.4 t ha\(^{-1}\) recorded significantly higher plant height, number of tillers and also recorded higher test weight, seed yield and protein content as compared to other treatments in wheat crops [35]. Use of vermicompost prepared from locally available organic materials (wheat straw, press mud cake and FYM), application of press mud cake (PMC) 50% and FYM 50% resulted in the highest plant height, number of tillers and seed yield in wheat Kumar [36]. Application of vermicompost at 6 t. ha\(^{-1}\) resulted in the highest nutrient uptake and it increased grain uptake of N, P and K by 51, 110 and 89% over control, respectively. Whereas, among fertilizer rates the highest uptake was produced by 100% NPK treatment and it increased the N, P and K uptake in the grain by 79, 100 and 96% over control, respectively [37].

**Use of Inorganic Fertilizer:** Nitrogen is the motor of plant growth and constitutes from 1 to 4 percent of the dry matter of the plant. Nitrogen is the key to soil fertility and an essential component of soil organic matter. About 90 - 95% of the total soil N is associated or combined with the soil organic fraction. Being the essential constituent of proteins, nitrogen is involved in all the major processes of plant development and yield formation. N is one of the essential macro elements needed by plants and has a greater limiting effect on plant productivity than any other element. Adequate N promotes vigorous growth and dark green color. On the contrary, N deficiency results in stunted growth and chlorotic leaves caused by poor assimilate formation that leads to premature flowering and shortening of the growth cycle [38]. The presence of N in excess amounts promotes the development of above ground organs with abundant dark green tissues of soft consistency and relatively poor root growth. This increases the risk of lodging and reduces the plant’s resistance to harsh climatic conditions and to foliar diseases [39]. A good supply of nitrogen for the plant is important also for the uptake of the other nutrients.

Crop response to nitrogen fertilizer varies with rate and time of application in relation to plant development. Nitrogen rate significantly influenced grain yield, protein content, N uptake efficiency, N biomass production efficiency, N utilization efficiency, N use efficiency for grain and N use efficiency for protein yield of wheat. In well-drained or oxidized soils, NO\(_3^-\) is present in higher concentrations compared to NH\(_4^+\). Hence, in aerobic soils, NO\(_3^-\) is the dominant form of N for plant uptake. In oxygen-deficient or reduced or anaerobic soils (such as flooded rice), the NH\(_4^+\) form of N is the dominant form and plants take this form of N in higher amounts compared to the NO\(_3^-\) form of N [40]. Mineral fertilizers are used to supplement the natural soil nutrient supply in order to satisfy the demand of crops with a high yield potential and produce economically viable yields; compensate for the nutrients lost by the removal of plant products or by leaching or gaseous loss. Nitrogen is commonly the most limiting nutrient for crop production in the major world’s agricultural areas and therefore adoption of good N management strategies often results in large economic benefits to farmers. Crop response to N fertilizer is influenced by factors such as nitrogen fertilizer management, soil type, crop sequence and supply of residual and mineralized nitrogen [41].

Application of N at the rate of 69 kg ha\(^{-1}\) gave more tillers, thousand seed weight, biomass, straw and grain yield than fertilizer applied 0, 23, 46, 69 and 92 kg ha\(^{-1}\) [42]. The new high yielding cultivars have a higher nutrient requirement because of their increased yield potential. Adequate Nitrogen application together with Phosphorus significantly increased number of tillers, plant height and number of grains per spike, 1000 grain weight and yield [43]. It can also increase phosphorus concentration in plants by increasing root growth and the ability of roots to absorb and translocate P and by decreasing soil pH as a result of absorption of NH\(_4^+\) which enhance solubility of Phosphorus.

**Integrated Nutrient Application for Improving Wheat Productivity:** Soil fertility decline is one of the constraints to food production in Sub-Saharan region. Low soil fertility in the region caused inherently low soil nutrient content and loss of nutrient through erosion and crop harvests. Soil fertility and crop yields are lower in developing countries due to loss of nutrients from farm lands exceeds inflows. Application of inorganic fertilizers together with organic manures were increased the total N content of soil than when used individually [44]. Similarly, Negessa [45] stated that the use of integrated soil fertility management strategy with inclusion and combination of chemical fertilizer, organic input and using improved crop varieties gives the better production and keeps the soil fertility status to a better level. Application of organic fertilizer not only increases the nutrient content of soils, but also improves the physical and biological condition of soils. Improvement in soil properties especially soil bulk density and soil structure enhance crop root development and distribution which enable soil
C and N cycles. A well-developed root system may play a dominant role in soil C and N and may have relatively greater influence on soil organic C and N levels than the above ground plant biomass. Roots can contribute from 400 to 1460 kg C ha$^{-1}$ during a growing season. Liang et al. [46] found that maize roots contributed as much as 12% of soil organic C, 31% of water-soluble C and 52% of microbial biomass C within a growing season.

Combined application of organic and inorganic fertilizers improved productivity of crop as well as soil nutrient content thus improves soil fertility status. Application of vermicompost along with chemical fertilizer significantly increased total N, available P, exchangeable K, Ca and Mg, available S, Zn and B with the increased levels of vermicompost and chemical fertilizer up to 50% while soil acidity was significantly decreased with the increased levels of vermicompost [47]. Thus, the technology not only supply essential nutrients and amends soil but also has some positive interaction to increase nutrient use efficiency, thereby reducing environmental hazards.

Different study been conducted under different soils conditions to evaluate crop performance under integrated application of organic and inorganic fertilizer. Edom et al. [48] obtained maximum yield and yield components of the same crop under vertisol condition by applying phosphorus and compost. Evidence from field experiment in northern region of the country also revealed that applications 6 t ha$^{-1}$ FYM and 46/46 kg ha$^{-1}$ N/P/O chemical fertilizer contributed as much as 12% of soil organic C, 31% of water-soluble C and 52% of microbial biomass C within a growing season.

Application of 100% recommended manure and compost as inorganic N equivalence also increased wheat grain yield by 110% and 55% compared to the control that is non-treated plot and farmers’ rate of 32/10 kg NP ha$^{-1}$ respectively (Table 1). The results of this study have clearly elucidated that if the application rate of fertilizers either as inorganic, organic or the combination of both is at least doubled under farmers’ field condition the yield gain will be more than double compared to the control plot and more than 50% compared to the farmers’ applied rate. Furthermore, the study proved the significance of the ISFM treatments containing both organic and inorganic forms under small holder farmer’s condition could be alternative options for sustainable soil and crop productivity in the highland vertisol of Ethiopia [51]. The works of different researchers showed that the integrated application of NP fertilizer with manure resulted in a significant increase in nutrient concentration and uptake, grain and straw yields of wheat [52].

The application of manure influences directly the availability of native or applied phosphorus. It was also found that the application of manure made the soil more porous and pulverized which allows better root growth and development and significantly increased the root CEC at each stage of growth, indicating that its application may prove beneficial for crop nutrition and yield. Gruhn et al. [53] reported that continuously cropped wheat, without the benefit of organic and inorganic fertilizers, typically has low yields (1.2 t ha$^{-1}$). The application of organic and inorganic fertilizers can increase average wheat yields to 6-7 t ha$^{-1}$. The author indicated that maximum wheat yields (9.4 t ha$^{-1}$) were also found when farmyard manure is applied together with inorganic fertilizers. The application of 60/20 kg NP ha$^{-1}$ and 30/10 kg NP ha$^{-1}$ with 50% manure and compost as N equivalence increased mean grain yield of wheat by 151 and 129% respectively compared to the control and by 85 and 68% respectively compared to the farmers’ treatment (23/10 kg NP ha$^{-1}$).

The major cause of low productivity of wheat in Ethiopia is decline in soil fertility. Use of chemical fertilizers particularly those bearing N and P have long been practiced to improve soil fertility for enhanced wheat and other crop production since these nutrients are the most limiting nutrients in most soils of the country. Several interventions particularly those geared towards nutrient management and soil moisture conservation have been recommended to address the problems. This is to increase crop yields for producing sufficient food by improving the use of fertilizers. Zaman et al. [55] reported that application of vermicompost in combination with chemical fertilizers gave greater biomass yield and nutrient uptake as well as improved soil properties over the sole use of chemical fertilizers.
Table 1: Effects of N, P and FYM on wheat yield on Nitisols of central Ethiopian highland

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moderately Fertile soil</th>
<th>Poor Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/P kgha⁻¹ FYM tha⁻¹</td>
<td>GY (t/ha)</td>
<td>BY (t⁻ha)</td>
</tr>
<tr>
<td>9/10/0</td>
<td>2.63³</td>
<td>7.10³</td>
</tr>
<tr>
<td>9/10/8</td>
<td>3.05³</td>
<td>8.56³</td>
</tr>
<tr>
<td>32/10/4</td>
<td>3.27³</td>
<td>9.18³</td>
</tr>
<tr>
<td>32/10/8</td>
<td>3.44³</td>
<td>9.77³</td>
</tr>
<tr>
<td>64/20/0</td>
<td>3.46³</td>
<td>10.06³</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>0.34</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Source: [50]

Table 2: Response of wheat grain yield (GY), total biomass (TB), straw yield (SY), harvest index (HI) and thousand grain weight (TGW) to ISFM treatments on Nitisols of central Ethiopian highland

<table>
<thead>
<tr>
<th>Treatments</th>
<th>GY</th>
<th>TB</th>
<th>Straw yield</th>
<th>HI</th>
<th>TGW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1258e</td>
<td>3644d</td>
<td>2387d</td>
<td>34.5bc</td>
<td>35.2</td>
</tr>
<tr>
<td>Farmer NPK rate (23/10/0)</td>
<td>1713d</td>
<td>4864c</td>
<td>2932c</td>
<td>35.2b</td>
<td>34</td>
</tr>
<tr>
<td>Recommended NPK (60/20/0)</td>
<td>3164a</td>
<td>7678a</td>
<td>4514a</td>
<td>41.2ab</td>
<td>33.2</td>
</tr>
<tr>
<td>50% recommended NPK (30/10/0) + 50% manure and compost as N equivalence (3.25 t/ha)</td>
<td>2882b</td>
<td>7073b</td>
<td>4192a</td>
<td>40.8ab</td>
<td>32.9</td>
</tr>
<tr>
<td>50% manure + 50%compost (6.5 t/ha) as N equivalence</td>
<td>2646c</td>
<td>6219c</td>
<td>3574b</td>
<td>42.5a</td>
<td>34.9</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>228.58</td>
<td>679.14</td>
<td>556.6</td>
<td>2.97</td>
<td>NS</td>
</tr>
<tr>
<td>CV (%)</td>
<td>9.35</td>
<td>11.94</td>
<td>15.41</td>
<td>7.18</td>
<td>7.22</td>
</tr>
</tbody>
</table>

Source: [54]

Table 3: Interaction effect of varieties, vermicompost and Nitrogen fertilizer on wheat grain yield

<table>
<thead>
<tr>
<th>Grain yield (t ha⁻¹) Varieties</th>
<th>Vermicompost (t ha⁻¹)</th>
<th>0</th>
<th>23</th>
<th>46</th>
<th>69</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danda’a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1.37³</td>
<td>1.82³</td>
<td>2.72¹</td>
<td>3.44³</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>1.95³</td>
<td>2.84³</td>
<td>3.47³</td>
<td>3.93³</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2.78³</td>
<td>3.74³</td>
<td>5.18³</td>
<td>4.96³</td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>3.21³</td>
<td>4.27³</td>
<td>4.98³</td>
<td>4.81³</td>
<td></td>
</tr>
<tr>
<td>Wane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1.57³</td>
<td>2.17³</td>
<td>2.67³</td>
<td>3.36³</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>2.11³</td>
<td>2.60³</td>
<td>3.67³</td>
<td>4.19³</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2.84³</td>
<td>3.65³</td>
<td>5.98³</td>
<td>5.52³</td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>3.30³</td>
<td>4.7³</td>
<td>5.74³</td>
<td>5.54³</td>
<td></td>
</tr>
<tr>
<td>LSD0.05</td>
<td>0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>5.2</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Source: [59]

Integrated applications of organic and inorganic fertilizers not only supply essential nutrients but also have positive impact on crop nutrient uptake and reduce environmental pollution. Integrated application of organic source with chemical fertilizers as well as increased in N rates resulted in the increase in N uptake with split dose of urea fertilizer application of vermicompost and has significantly increased nutrient uptake, yield and yield components of wheat [56]. They concluded that wheat responds significantly to application of vermicompost and NPK fertilizers suggesting that nutrient contents of experimental soil are low for optimum production of wheat. Positive response was obtained with the application of vermicompost to other field crops such as sorghum [57]. Field experiment was conducted under acidic Nitisol condition of welmera district central high lands of Ethiopia by Negessa [58] indicated that significant improvement in wheat production. The author found that combined application of wane variety, 5 t. ha⁻¹ of vermicompost and 46 kg ha⁻¹ nitrogen fertilizer obtained the highest grain yield in the area.

CONCLUSION AND RECOMMENDATIONS

Integrated soil nutrient management plays a critical role in improving nutrient availability and building soil organic matter and enhancing crop productivity in most smallholder farming systems in the country.
Different work conducted at different time in different parts of the country exhibited that integrated application of organic and inorganic fertilizers improved the fertility status of soil hence the productivity of wheat. The management approach notably preferred option in replenishing soil nutrient and enhancing productivity of wheat however the technology did not widely take up by many farmers as a result of lack of availability of inputs, un-accessibility to mineral fertilizer, limitation of organic sources and use of crop residue for energy source. There is a need for research and extension to sort out issues of adoption and scaling up of the available technology. Therefore, in order to address soil fertility problems, potential synergies could be gained by combining technical options with farmers’ knowledge as well as training of farmers and development agent on new soil nutrient management approaches.

REFERENCES


