



# The Effect of Integrated Organic and Inorganic Fertilizer on Soil Fertility and Productivity

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## Abstract

Soil fertility depletion is a main problem to sustain agricultural production and productivity in many countries. The use of inorganic (chemical) fertilizer or organic fertilizer alone has both positive and negative effects on plant growth, nutrient availability and the soil. Inorganic fertilizer is usually immediately and fast containing all necessary nutrients that are directly easy to get for plants. But continuous use of inorganic (chemical) fertilizers alone causes soil organic matter degradation, soil acidity and environmental pollution. However, Organic fertilizer improves physical and biological activities of soil, but comparatively organic fertilizers has lower nutrient content, because of that larger quantity of fertilizer is required to adequate nutrient for plant growth. So integrated or mixed inorganic and organic nutrient management system is an alternative system for the sustainable and cost effective management of soil, and the result is raising soil fertility and productivity without affecting environment. The objective of the review is to assess the effect of mixing organic with inorganic fertilizer on soil fertility and productivity. The study revealed that appropriate application of organic with inorganic fertilizers increases the productivity without negative effect on productivity and improves soil fertility than the values obtained by organic or inorganic fertilizers separately.

**Keywords:** Integrated nutrient management; Organic fertilizer; Inorganic fertilizer; Soil and Productivity

## Introduction

In Ethiopia, century-long, low-input agricultural production systems and poor agronomic management practices, limited awareness of communities and absence of proper land-use policies have aggravated soil fertility degradation. Agriculture is the basis of the majority of the population and major driver of the national economy. Agricultural production has been highly dependent on natural resources for centuries [1,2]. However, increased human population and other factors have degraded the natural resources in the country thus seriously threatening sustainable agriculture and food security [3,4]. Continuous cropping and inadequate replacement of nutrients removed in harvested materials or lose through erosion and leaching

has been the major causes of soil fertility decline [5]. This is particularly evident in the intensively cultivated areas, traditionally called high-potential areas that are mainly concentrated in the highlands of Ethiopia. To tackle this problem, the country initiated community-based participatory watershed management [6], and to date, it has rehabilitated millions of hectares of degraded land. Decline in soil fertility due to long-term cultivation with little or no fertilizer additions is the major form of land degradation in most of sub-Saharan Africa. Soil fertility maintenance is a major concern in tropical Africa, particularly with the rapid population increase, which has occurred in the past few decades. In traditional farming systems, farmers use bush fallow, plant residues, household refuse, animal manures and other organic nutrient sources to maintain soil fertility and

soil organic matter. Soil fertility decline is the pressing issue in sub-Saharan Africa [7-10]. Soil degradation is the most serious bio-physical constraint limiting crop productivity in Ethiopia [11,12]. The problem is more serious in the highlands where most of the human and livestock population is found. A recent study has showed that the average annual soil loss from agricultural land is estimated to be 137 tons ha<sup>-1</sup> per year for the Ethiopian highlands, which is approximately an annual soil depth loss of 10mm [12,13].

Declining soil fertility has also been stressed to be the fundamental impediment to agricultural development and the major reason for the slow growth in food production in Ethiopia [14]. The loss of soil nutrients in Ethiopia is related to cultural practices such as low fertilizer use, removal of vegetative cover (such as straw or stubble) and burning plant residues or the annual burning of vegetation on grazing land [15]. The crops that are commonly grown on Vertisols of Ethiopia are teff, bread wheat, barley, chickpea, lentil and niger seed [16]. Recently, farmers in Ethiopia are using modified plough called broad bed maker (BBM) and harvesting higher yields from multiple crops on the same plot of land per season [17]. Previously, only nitrogen (N) and phosphorus (P) were considered to be the limiting nutrients in Vertisols of Ethiopia [18]. However, many soils in the highlands of Ethiopia are poor in available plant nutrients and organic matter content [19]. Recently, the results of national soil fertility mapping initiative has also indicated that other nutrients including K, S, Fe, Zn and B are also found to be deficient in these soils [20]. In addition to the high fixing characteristics of Vertisols [21], lack of response to P application on central highland Vertisols of Ethiopia may be due to deficiency of nutrients other than P.

The prevailing soil and environmental conditions not only reduce the efficacy of mineral fertilizers, but also ultimately affect the productivity of crop [22]. Soil fertility degradation, poor crop management, nutrients deficiency and imbalanced fertilizations are the critical factors reducing wheat yield in many countries of the world [23]. Continuous application of inorganic fertilizers to soil not only threaten the environment, but also pollute the surface and sub-surface water reserves by leaching down into the soil [22].

### **Factors that affect soil fertility**

Ethiopia are cultivation on steep and fragile soils with insufficient investments in soil conservation or vegetation cover, erratic and erosive rainfall patterns, declining use of fallow, limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, deforestation and overgrazing [24,25]. Therefore, reducing resource degradation, increasing agricultural productivity, reducing poverty, and achieving food security

are major challenges of the countries in tropical Africa. Thus, every effort should be directed to maintain the physical, biological and socio- economic environment for production of food crops, livestock, wood and other products through sustainable use of the ecosystem.

### **Effect of organic fertilizer on soil fertility and productivity**

Organic fertilizers are natural materials of either plant or animal source, including livestock manure, green manures, crop residues, household waste, compost, sewage sludge, food industry wastes and works directly as a source of plant nutrients and indirectly influences the physical, biological and chemical properties of soil [26,27]. Application of organic manure improves soil organic matter content, as well as the total nitrogen content of the soil [28]. Organic fertilizers have advantages to improve soil fertility: increasing organic matter in soil which improves the soil structure, creating more air space and water retention within the soil and enhances soil nitrogen content, enhanced nutrient availability, releasing nutrients at a slower and more reliable rate, improves nutrient mobilization and protect the soil against rain and wind erosion [29,30]. The use of organic soil inputs in the form of FYM, conventional compost and vermi-compost is very important. However, our small-scale farmers lack the Knowledge on the rate, quality, and of course alternate sources of these fertilizers.

Organic fertilizers are improve soil fertility: increasing organic matter in soil which improves the soil structure, creating more air space and water retention within the soil and enhances soil nitrogen content, enhanced nutrient availability, releasing nutrients at a slower and more consistent rate, improves nutrient mobilization and Protect the soil against rain and wind erosion [30]. Organic fertilizer enhances soil biological activity and the colonization of mycorrhizae. That enhances mutuality association between fungi and higher plants. Organic fertilizer increase root growth due to enhanced soil structure, promoting soil aggregates, enhances cation exchange capacity [31]. However, organic farming systems avoid the application of inorganic fertilizers and instead rely upon crop rotation, manures, organic amendments, and the biological systems of nutrients mobilization to maximize yield [32].

### **Disadvantage of organic fertilizer on soil fertility and productivity**

Excessive application of organic manure should be avoided, particularly in soil, to reduce the risk of toxic effects from reduced metabolic intermediates [33]. In fact, organic manure alone might not meet the plant's requirements due

to the relatively low nutrient contents and the slow release of plant nutrients [34]. Uses organic manures alone have some limitation too, organic fertilizers are derived from substance like animal feces or plant matter contaminated with pathogen, which are extremely dangerous to human, as well as plants; in addition, organic fertilizers are relatively low in nutrient content and hence required in huge amount to supply proper amount of nutrients to the crops [10].

### **Effect of inorganic fertilizer on soil fertility and productivity**

The addition of chemical fertilizers might be essential because chemical fertilizers can re-establish the soil fertility very quickly and the nutrients are obtainable to the plants as soon as the fertilizers are dissolved in the soil [35]. Inorganic fertilizer increases root residues that mean indirectly increases organic matter. Inorganic fertilizers are good for rapid growth of plants because the nutrients are already water soluble. Therefore the effect is usually immediately and fast, contains all necessary nutrients that are ready to use. Inorganic fertilizers are quite high in nutrient content and only relatively small amounts are required for productivity. Application of correct amount of inorganic fertilizer can increase soil organic matter through higher levels of root mass and crop residues [36]. Due to this recently farmers put an emphasis on chemical fertilizer application in order to increase productivity [37]. Using inorganic Fertilizer is very important to increase crop production and soil fertility improvement.

### **Disadvantage of inorganic fertilizer on soil fertility and productivity**

Chemical fertilizer enhances the decomposition of soil organic matter, which leads to degradation of soil structure and decrease in soil aggregation results in nutrients are easily lost from soils through fixation, leaching, gas emission and can lead to diminish fertilizer efficiency [38]. Excessive or inappropriate application of chemical fertilizers (CFs) is a major cause of nutrient imbalance in soil, leading to high losses, particularly of N from the fertilizer, low N recovery (30%) [39]. Unnecessary and excessive application of inorganic fertilizers causes environmental damage, pollution of water sources, and decreases beneficial living organisms [40].

The other effect of inorganic (chemical) fertilizers are increase soil acidity. Acidification impacts negatively on the soil ecosystem thereby causing damage to plants. It also results in the alteration of soil water chemistry. Soil acidification results from pH decline or from acid deposition. The phenomenon of acid deposition arises

from the deposition of emissions from vehicles such as SO<sub>2</sub>, power stations, other industrial processes and natural biogeochemical cycles onto the soil surface mainly via rainfall and dry deposition [41].

### **Effect of Integrated Organic and Inorganic fertilizer on soil fertility and productivity**

Research has identified intensification options in agricultural production including integrated options combined use of organic and inorganic inputs, micro dosing of fertilizers, legume-cereal integration through rotations and intercropping, conservation agriculture and agroforestry options, among others [42]. The use of external inputs is a nutrient management option that has attracted the most studies in SSA. Several decades of research show that deficiencies of macronutrients such as N, P, and K are major limitations to crop production, and recently the limitations of secondary nutrients and micronutrient deficiencies are gaining traction [43-45].

The basic concept underlying the integrated nutrient management remains the maintenance and possible improvement of soil fertility for sustained crop productivity on long-term basis and also reduction of fertilizer inputs [46]. Organic farming approach with chemical fertilizers seems to be the best possible solution to increase crop growth [47]. The most common chemical fertilizers used in Ethiopia are diammonium phosphate (DAP) and urea. Chemical fertilizers are also becoming very costly for farmers to apply the full recommended rates.

Integrated Plant Nutrition Management (IPNM) can be the best alternate approach for better crop production and sustainable soil health, the best possible way to increase soil productivity, as well as soil fertility is the integration of both inorganic and organic fertilizers [48]. The integrated use of chemical and organic fertilizers improves plant growth and increases rice yield and quality [49]. Integrated use of N and P and FYM are better than application of either N and P or FYM alone for maize production [50]. Similarly, [51] indicated that application of FYM every three years at the rate of 16 t ha<sup>-1</sup> supplemented by N and P fertilizer annually at the rate of 20-46 kg N-P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> was recommended for sustainable maize production around Bako area. Therefore, it is important to explore the efficacy of combination organic and inorganic fertilizers on growth performance, yield potential, and grain quality of the production and productivity.

### **Conclusion**

This review showed that, continuous application of inorganic (chemical) fertilizers is the main reason for declining soil fertility. In this time, farmers use inorganic

(chemical) fertilizer widely. It is simple for application, transportation and fast containing all necessary nutrients that are directly easy to get for plants. But continues application of chemical fertilizer is affect organic matter of soil. Organic fertilizer is improve soil physical and biological properties, but the nutrients may not be as readily available to the plants. Fertilizer application of organic or inorganic fertilizer alone is not effective for soil fertility and productivity. For sustainable agricultural system, integrated soil fertility management is an approach that attempts to make the best use of inherent soil nutrient stocks, locally available soil amendment and mineral fertilizers to increase land productivity and maintaining or enhancing soil fertility.

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