academicresearchJournals

Vol. 4(3), pp. 93-104, March 2016
DOI: 10.14662/ARJASR2016.010

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

***Academic Research Journal of Agricultural Science and Research***

***Full Length Research***

# A review on impact of compost on soil properties, water use and crop productivity

**Getinet Adugna**

Ethiopian Institute of Agricultural Research; Werer Research Center P.O Box 2003, Addis Ababa, Ethiopia. Mobile: +251 911 39 11 24 Email: getinet03@gmail.com

Accepted 25 April 2016

**The review summarizes the literature and the current knowledge on the effect of compost fertilization on the soil plant system. Most of investigators confirmed that compost application could improve the physical, chemical and biological characteristics, soil organic matter, and nutrient status of the soils. All long-term compost application trials result in increased SOM concentrations. However, mature composts increase SOM much better than fresh and immature composts due to their higher level of stable carbon. In addition, due to its multiple positive effects on the physical, chemical and biological soil properties, compost contributes to the stabilization and increase of crop productivity and crop quality. Consequently, most investigators proved that compost has an equalizing effect of annual/seasonal fluctuations regarding water, air and heat balance of soils, the availability of plant nutrients and thus the final crop yields. Predominantly because of the slow release of nutrients and its availability in compost-combined fertilization schemes often show good results. Thus, for sustainable agricultural systems within small-scale farming in developing countries like Ethiopia, composting can be a good option for developing effective plant-nutrient management strategies in many situations.**

**Key words:** Crop productivity, matured compost, soil organic matter, plant nutrients, soil physical property, soil chemical property, soil biological property

## INTRODUCTION

Compost use is one of the most important factors, which contribute to increased productivity and sustainable agriculture. In addition, compost can solve the problem faced on farmers with decreasing fertility of their soil. Due to soil fertility problems, crops returns often decrease and the crops are more susceptible to pest and disease because they are in bad condition (Madeleine et al., 2005).

Compost consists of the relatively stable decomposed organic materials resulting from the accelerated biological degradation of organic materials under controlled, aerobic conditions (Paulin and Peter, 2008). Compost fertilizer is made from plant and animals remains with the objectives of recycling plant and animals remains for crop production. The decomposition process converts potentially toxic or putrescible organic matter into a stabilized state that can improve soil for plant growth. Composted organics has other beneficial effects, including diverting landfills wastes to alternative uses, removal of pathogen inocula or weed seeds and decomposition of petroleum, herbicide or pesticide residues, erosion control and as a nutrient source for sustainable re- vegetation of degraded soils. Using compost can improve the capacity to produce safe ‘clean green' horticultural produce and importantly increase the potential for large-scale organic food production (Paulin and Peter, 2008).

The presence of organic matter in the soil is fundamental in maintaining the soil fertility and decreasing nutrient losses. Thus, compost is a good organic fertilizer because it contains nutrients as well as organic matter. Organic matter has number of important roles to play in soils, both in their physical structure and as a medium for biological activity. In addition, organic matter makes its greatest contribution to soil productivity. It provides nutrients to the soil, improves its water holding capacity, and helps the soil to maintain good tilth and thereby better aeration for germinating seeds and plant root development (Edwards and Hailu, 2011).

Moreover, soil fertility is associated with mineralization of nutrients contained in organic matter and their release in plant- available form to the soil solution. Mineralization is the result of normal biological cycles within the soil and can be stimulated by the addition of appropriate quality compost and cultivation (Paulin and Peter, 2008). Because mineralization occurs over extended periods it can make important contribution to plant growth and to minimizing the impact of leaching associated with rainfall and excess irrigation (Paulin and Peter, 2008). On the other hand, adding artificial fertilizer alone is not sufficient to retain a sufficient level of soil fertility. Organic matter is needed to retain the water and nutrient. In degraded soil, where there is little organic matter, yields response is limited, even if artificial fertilizer are being used (Madeleine et al., 2005). Hence, the farmers need to take care of the organic matter content of the soil. An integrated approach, combing application of compost with an application of artificial fertilizer is a good strategy for sustainable crop production (Gete et al., 2010).

In Ethiopia soil erosion and declining of fertility is a serious problem to agricultural productivity and economic growth (Gete et al., 2010). Average soil removal all over the country was estimated to be about two billion tons per year (CSA, 2001). Hence, to sustain the balance of soil fertility and reduce soil erosion, and to ensure agricultural productivity adoption of composting technology and application of amenable compost is quite essential. Therefore, the objective of this paper is to review the significance of compost preparation and use, and its effect on soil properties, water use and crop productivity.

## Effects of Compost on Soil Properties

### Soil organic matter

Organic additions to soil have long been considered important in maintaining the quality of both natural and managed soils, principally because of their role in providing nutrients and through their role in influencing soil physical properties. In farming systems, before the widespread introduction of manufactured fertilizers organic residues were the only means of adding many nutrients to the soil, in particular Nitrogen. In non-cultivated soils, it is likely that more than 95% of the Nitrogen and Sulfur is found in the soil organic matter, and possibly as much as 25% of the Phosphorus (Amlinger et al., 2007).

One efficient way to increase SOM level is compost application, produced especially from biomass wastes. However, the essential influencing factors for SOM-enrichment are quantity, type and degree of humification of compost, the soil properties (soil type; clay content) and managements. Mature composts increase SOM much better than fresh and immature composts due to their higher level of stable C (Bouajila and Sanaa, 2011 and Daniel and Bruno, 2012)**.** In addition, high amount of OM in compost increased OC in both soil and OC amount in uncultivated soil was higher than cultivated soil because of plant cultivation effect and increase of OM degradation in cultivated soil (Soheil et al. 2012).

Bouajila and Sanaa (2011) reported that application of manure and household wastes compost resulted in significant increase of organic carbon, with the compost treatment being the most efficient. Their result showed that the application of 120 t/ha household wastes compost and manure improved an organic carbon (1.74 % and 1.09 %, respectively) when compared with control (0.69 %). Soheil et al. (2012) was investigated, applying compost to soil increases the amount of soil OC with increases rate of compost application (Table 2 and 4). Mohammed et al. (2004) was also conducted an experiment of use of composted organic wastes as alternative to synthetic fertilizers in two different seasons (Wet and dry) on the Tropical Island of Guam. The results of the trial indicated that land application of organic compost enhanced soil quality and increased soil fertility and crop yield. As shown in Table 1, considerable improvement in soil organic matter content was occurred with the application of composted organic material.

There are few trials, which show no significant differences in SOM level by the application of diverse C sources (straw, manure, compost). However, the majority of studies of different authors have unambiguously proven a better humus reproduction for composted materials (Agegnehu et al., 2014 and Amlinger et al., 2007). According to Amlinger et al., 2007, the average SOM demand of agriculturally used soils can be met by applying 7 – 10 Mg (dry matter) compost $ha^{-1}$. Therefore, for a long-term increase of SOM, more than 10 Mg dry matter compost $ha^{-1}$ is required.

**Table 1.** Showing improvement for some of the soil physical and chemical properties as they are affected by different treatment from the first trail during the dry season (March – June, 2003)

| Treatment | Bulk Density (gm/cm $^3$) | Organic Matter (%) | Moisture Content (%) | NO3 (ppm) | P (ppm) | K (ppm) | Ca (ppm) | Mg (ppm) |
|---|---|---|---|---|---|---|---|---|
| 0 t/a(cont) | 1.18 | 5.36 | 26.01 | 3.28 | 30.09 | 206.83 | 3416.17 | 171.40 |
| 30 t/a | 1.01 | 5.64 | 25.86 | 4.96 | 52.34 | 744.97 | 3779.88 | 297.59 |
| 60 t/a | 0.98 | 6.57 | 28.07 | 5.89 | 61.02 | 1053.36 | 4748.70 | 431.20 |
| 120 t/a | 0.91 | 9.46 | 32.16 | 16.01 | 76.65 | 1418.70 | 5492.18 | 787.92 |

Source: Mohammad et al. (2004)

**Table 2**: The effects of MWC on soil properties (Soheil et al., 2012)

| Treatment (t ha$^{-1}$) | PH | EC (dsm$^{-1}$) | OC (%) | N (%) | Available (mg Kg$^{-1}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | P | K | Fe | Mn | Zn | Cu | Pb | Ni | Cd |
| Control | 6.83 a | 0.9 d | 0.16 d | 0.05 c | 14 d | 111 d | 2.2 d | 2.3 c | 0.09 c | 1.4 c | 1.4 c | 0.08 d | 0.028 c |
| 15 | 6.89 a | 1.2 c | 0.24 c | 0.06 bc | 33 c | 123 c | 2.4 c | 2.4 b | 1.1 b | 1.5 b | 1.5 b | 0.1 c | 0.045 bc |
| 30 | 6.71 a | 1.5 b | 0.43 b | 0.07 ab | 53 b | 143 b | 2.5 b | 2.5 a | 1.5 a | 1.83 a | 1.6 b | 0.2 b | 0.047 ab |
| 60 | 6.94 a | 1.7 a | 0.65 a | 0.08 a | 69 a | 192 a | 2.7 a | 2.7 a | 1.54 a | 1.87 a | 1.69 a | 0.3 a | 0.055 a |

Means with common letter in each column are not significantly different at p<0.05 according to Duncan

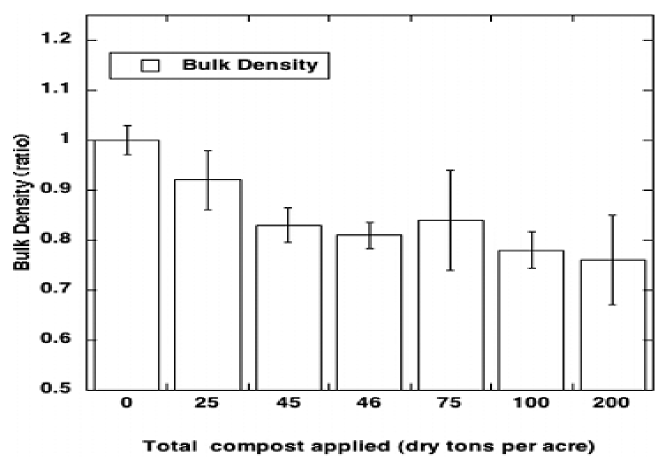



**Figure 1.** Soil bulk density in compost amended soils (ratio of observed values in amended soils in comparison to the control soils) (Brown and Cotton, 2011). Values <1 indicates reduced bulk density in comparison to the control soils.

## Effects Compost on Soil Physical Properties

### Reduction of bulk density

Compost application generally influences soil structure in a beneficial way by lowering soil density due to the admixture of low density organic matter into the mineral soil fraction. This positive effect has been detected in most cases and it is typically associated with an increase in porosity because of the interactions between organic and inorganic fractions (Amlinger et al., 2007). Brown and Cotton (2011) have observed that soil bulk density followed a predictable pattern with decreased bulk density at increasing rate of compost (Figure 1). Low bulk

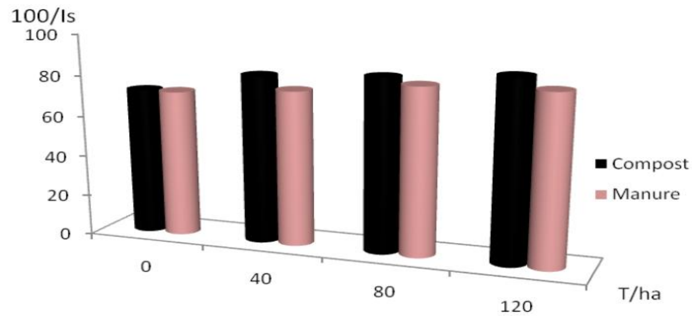



**Figure 2.** Changes in the structural stability in amended parcels with manure and compost (Bouajila and Sanaa, 2011)

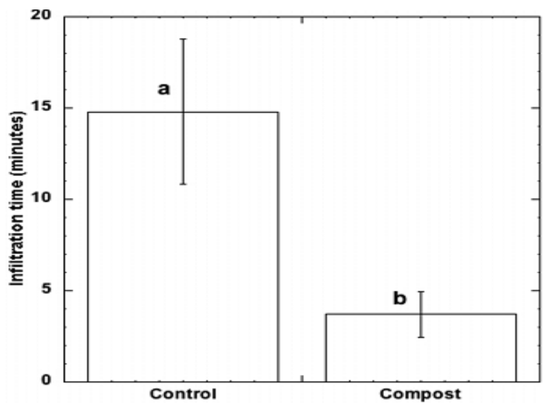



**Figure 3.** Water infiltration (minutes) for all compost amended and control soils with the same soil sries (Brown and Cotton, 2011).

density indicates increased pore space and is indicative of improved soil tilth. In this respect, compost increases the portion of meso- and macro-pores because of an improved aggregation and stabilization of soil significantly initiated by various soil organisms (Liu et al., 2007). In addition, the organic fraction is much lighter in weight than the mineral fraction in soils. As the result, increases in the organic fraction decrease the total weight and bulk density of the soil (Brown and Cotton, 2011).

**Increase of aggregate stability**

In general, soil structure is defined by size and spatial distributions of particles, aggregates and pores in soils. The volume of solid soil particles and the pore volume influences air balance and root penetration ability. As a general fact the more soil structure is compacted, the more unfavorable are the soil conditions for plant growth. By incorporation of compost into the soil, aggregate stability increases most effectively in clayey and sandy soils. Positive effects can be expected by well humified (promoting micro-aggregates), as well as fresh, low-molecular OM (promoting macro-aggregates). Macro-aggregates are mainly stabilized by fungal hyphen, fine roots, root hair and microorganisms with a high portion of easily degradable polysaccharides (Amlinger et al., 2007). Besides clay minerals and oxides, fine roots, hyphen networks as well as glue-like polysaccharides originated from root and microbial exudates significantly contribute to the formation of micro-aggregates.

Besides, the compost quantity, the type of compost (fresh or mature compost), the intervals of application and above all the soils on which compost will be applied influence the effect of compost. The field trial of Bouajila and Sanaa (2011) showed that application of manure and household wastes compost resulted in significant increase of structural stability, with the compost treatment being the most efficient (Figure 2). Their results also indicated that the application of 120 t/ha household wastes and manure improved better the structural stability when compared with control. Such behavior might be the result of elevated organic matter content and important microbial activities (Amlinger et al., 2007).

Furthermore, aggregate and pore properties of soils are associated with specific “active” surface area influencing several storage and exchange processes in soil. The higher the specific surface area, the more intensive

**Table 3:** The effects of municipal waste compost (MWC) on concentrations of N, P, K and concentrations of micronutrients / heavy metals and yield in corn (Soheil et al., 2012)

| Treatment (t ha$^{-1}$) | Mean stem height (cm) | Dry matter (g) | Concentration (%) | | | Concentration (mg kg$^{-1}$DM) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | Fe | Mn | Zn | Cu | Pb |
| Control | 31 d | 3.6 d | 3 c | 0.1 d | 1 d | 140 c | 97 d | 13.5 c | 55d | 0.2 d |
| 15 | 38.7 c | 6.2 c | 3.4 c | 0.2 c | 1.2 c | 166 c | 105 c | 14.5 b | 61 c | 1.9 c |
| 30 | 44.5 b | 6.8 b | 4.5 b | 0.3 b | 1.4 b | 256 b | 129 b | 14.7ab | 68 b | 3.3 b |
| 60 | 49.2 a | 7.3 a | 5.3 a | 0.37 a | 1.6 a | 517a | 134a | 14.9 a | 71 a | 5.1 a |

Means with common letter in each column are not significantly different at p<0.05 according to Duncan Multiple Range Test

interactions can occur between soil fauna, microorganisms and root hairs under optimum conditions (e.g. sufficient humidity). As a result, a high specific surface area can create the prerequisite for an optimal soil formation (Amlinger et al., 2007).

### Water holding capacity and infiltration

The amount of water that is available to a plant will depend on two factors: the quantity of water that is able to infiltrate into the soil and the quantity of water that the soil is able to hold onto. Field capacity and available water holding capacity are generally influenced by the particle size, structure and content of OM. However, clay soils, due to higher matric potential and smaller pore size will generally hold significantly more water by weight than sandy soils. In this respect, Brown and Cotton, (2011) have indicated that while overall, texture is the primary factor affecting water holding capacity, increasing organic carbon is a significant factor for improving soil water holding capacity. They also confirmed that compost application had the greatest effect on soil water holding capacity on coarser textured soils with smaller to no change in water holding capacity on finer textured soils. Further they have observed the effect of compost addition on soil infiltration rate. Across all soils, compost addition increased water infiltration rate compared to the control (Figure 3).

Other authors (Bouajila and Sanaa, 2011) reported similar results that organic amendments allowed better water infiltration. Thier result showed that the application of 120 t/ha household wastes compost and manure improved water infiltration (549.25 and 596.46 cm, respectively) when compared with control (332.16 cm). Additionally, increased infiltration is another indication of increased efficiency in water use as a higher fraction of irrigation or rainfall is likely to enter soils with higher infiltration rates. More rapid infiltration is associated with reduced runoff, better aeration, and improved irrigation efficiency (Daniel and Bruno, 2012). As with water holding capacity, soil texture has a significant effect on infiltration rate. However, unlike water holding capacity, the largest improvement would be expected in fine texture soils that tend to be poorly drained. In the study, the largest improvements in water holding capacity were seen in the coarse textured or sandy soils while the largest improvements in water infiltration rate were observed in the finer textured soils (Brown and Cotton, 2011). Similarly, composted cattle manure applied to the soils showed a positive effect, improving infiltration and decreasing runoff volumes by up to 20% (Ramos and Marttinez-Casasnovas, 2006).

Furthermore, reduced erosion is mainly related to the improved soil structure by the addition of compost, which, in turn, is pointed out by better infiltration rate, pore volume and enhanced stability through aggregation. According to Amlinger et al. (2007), experimental trials showed a clear correlation between increases of SOM, reductions of soil density, soil loss and water run-off. Strauss (2003) has quantified the effect of compost on soil erosion in detail. Five years long compost application resulted in 67% reduced soil erosion, 60% reduced run-off, and 8% lower bulk density and 21% higher OM content compared to control plots.

## Effects on soil chemical properties

### Enhancement of nutrient level

Compost contains significant amounts of valuable plant nutrients including N, P, K, Ca, Mg and S as well as a variety of essential trace elements (Agegnehu et al., 2014 and Madeleine et al., 2005). Thus, compost can be defined as an organic multi nutrient fertilizer (Amlinger et al., 2007). Its nutrient content as well as other important chemical properties like C/N ratio, pH and electrical conductivity (EC) depends on the used organic feedstocks and compost processing conditions. By an appropriate mixture of these, organic input materials, humus and nutrient-rich compost substrates can be produced which serving as a substitute for commercial mineral fertilizers in agriculture (Amlinger et al., 2007).

However, their diverse beneficial properties for amelioration outreach their nutrient content.

Soheil et al. (2012) determined the effects of Municipal Waste Compost (MWC) on soil chemical properties and corn plant responses in pot experiment. They found that the amount of available N, P and K and micronutrient/heavy-metal concentrations in soil increased as the result of waste compost application (Table 2). The increases were significant for all concentrations, especially for 60 t $ha^{-1}$ treatment. They also tested the concentrations of N, P, K and micronutrient elements in the dry matter of the aerial part of the plant (Table 3). The result showed that N, P and K content and concentration of micronutrients in plant increased with increase of compost concentration. Amount of the waste compost was significantly increased concentrations of macro and micronutrients in dry matter; also, they had significant effects on concentrations of heavy metals. However, the content of concentration of cations was higher in plants exposed to 60 t $ha^{-1}$ to 4 Kg soil compost concentration than the rest concentrations and control.

According to Soheil et al. (2012) research results, the application of large quantities of MWC may contaminate soils with heavy metals or other toxic elements. Significant differences were observed between treatments and the treatment 60 $tha^{-1}$ have shown highest effects on soil and corn properties. However, to apply these kinds of fertilizers we should notice the quantity and available forms of heavy metals and their additive effects on soils and plants like corn and also we should notice the excessive quantity of elements and their toxicity and salinity to soils and plants yield like corn and use favorable managements. In general, the content of several ions in the compost is of potential nutritional value to plants, especially when the heavy metals content are low, but high concentrations of some ions can potentially increase salinity soils (Soheil et al. (2012).

In another study, Brown and Cotton (2011) suggested that compost amended soils contain comparable concentrations of plant available nutrients compared to conventionally fertilized soils and elevated concentrations of macro- and micronutrients in comparison to control soils. Gamal (2009) has also conducted the experiment by applying 0 ton, 5 ton, and 10 ton $ha^{-1}$ rates of compost and tested the nutrient content at harvest. He observed increased N, P and K nutrients content in all compost received plots and this increase was higher in plots receiving 10 ton $ha^{-1}$ of compost. With respect to micronutrients, increased uptake of Cu, Mn and Zn were reported (Amlinger et al., 2007). Bouajila and Sanaa (2011) have also reported that the application of increasing manure and waste household compost concentrations (40 and 120 t/ha) resulted in significant increase of organic nitrogen (Figure 4).

However, total nutrient content of compost is not plant-available fully at once. This can be ascribed to the existence and different intensity of various binding forms within the organic matrix, which result in a partial immobilization of nutrients (Tayebeh et al., 2010). On the other hand, the fertilization effect will last longer due to a slow and gradual release of plant nutrients (Seran et al., 2010). Therefore, with compost there is a much better protection from leaching compared to soluble mineral fertilizers. Especially the N fertilization effect of compost is limited due to low mineralization rates and microbial immobilization (Tayebeh et al., 2010).

**Increase of Cation Exchange Capacity (CEC)**

The CEC is one of the most important indicators for evaluating soil fertility, more specifically for nutrient retention and thus it prevents cations from leaching into the groundwater. Agegnehu et al. (2014); Jamal (2009) and Mohammad et al. (2004) proved that compost amendment resulted in an increase of CEC due to input of stabilized OM being rich in functional groups into soil. In Mohammad et al. (2004) study, following the first harvest from dry season the same plots were used for re- planting during the wet season. Data obtained from the second trail indicated that as the compost application rates were increased from 0 tons per acre to 120 tons per acre the soil CEC as one of the major soil quality indexes were also increased (Table 4) indicating a considerable improvement in nutrient exchange capacity of the soils treated with organic matter amendments. According to Amlinger et al. (2007), soil organic matter contributes about 20 – 70% to the CEC of many soils. In absolute terms, CEC of organic matter varies from 300 to 1,400 $cmol_c$ $kg^{-1}$ being much higher than CEC of any inorganic material.

**Increase of pH value, liming effect and improved buffering capacity**

Soil pH is an indicator for soil acidity or soil alkalinity and is defined as the negative logarithm of hydrogen ions activity in a soil suspension. It is important for crop cultivation because many plants and soil organisms have a preference for slight alkaline or acidic conditions and thus it influences their vitality. In addition, pH affects availability of nutrients in the soil. Compost application has a liming effect due to its richness in alkaline cations such as Ca, Mg and K, which were liberated from OM due to mineralization (Agegnehu et al., 2014 and Daniel and Bruno, 2012). Similarly, regular applied compost material maintains or enhances soil pH (Jamal, 2009 and Soheil et al., 2012). Only in some few cases, a pH decrease was observed after compost application

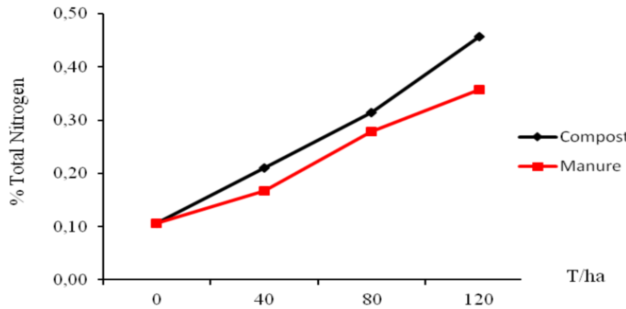



**Figure 4.** Variations in the total nitrogen percentage in soils amended with manure and compost (Bouajila and Sanaa, 2011)

**Table 4.** Showing improvement for some of the soil physical and chemical properties as they are affected by different treatment from the 2nd trail during the wet season (August - October, 2003)

| Treat | pH | OM (%) | Db ($gr/cm_3$) | Ca Mg/kg | Mg | K | $No_3$ | P | CEC(Meq /100g) |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 T/A | 7.9 | 3.4 | 1.03 | 3178.6 | 625.6 | 217.0 | 13.1 | 17.8 | 2.17 |
| 30 T/A | 7.8 | 4.6 | 0.98 | 3300.6 | 1018.9 | 485.4 | 40.5 | 35.8 | 2.62 |
| 60T/A | 7.8 | 5.4 | 1.02 | 3495.1 | 1564.6 | 748.5 | 55.5 | 44.6 | 3.24 |
| 120T/A | 7.6 | 7.2 | 1.01 | 4312.4 | 2072.4 | 1064.7 | 76.7 | 58.4 | 4.16 |

Source: Mohammad et al. (2004)

(Mohammod et al., 2004).

Kluge (2006) also confirmed a significant increase of the pH value even at moderate compost applications. A mean increase of the pH value of 6.4 to 6.8 at 10 Mg d.m. compost $ha^{-1}a^{-1}$ was appeared (Figure 5). Thus a supply of annually 200 – 400 Kg CaO $ha^{-1}$at compost applications between 6 and 7 Mg d.m.$ha^{-1}$corresponds to preservation or maintenance liming and stabilization of the pH value (kluge, 2006).

## Effects of compost on water use

To ensure effective production of permanent sustainable development of agriculture systems, minimizing negative effects on environment, especially on sources of water and soil fund is necessary. That means, among others, to hinder soil degradation leading to nutrient losses and organic matters losses linked with rapid reduction of biologic productivity and soil quality. One of the causes of such degradation is soil's lower ability to retain water. An ability of soil organic matter to bind water has become an important theme for research in the past years.

Compost does several things to benefit the soil that synthetic fertilizer cannot do. First, it adds organic matter, which improves the way water interacts with the soil. In sandy soils, compost acts as sponge to help retain water in the soil that would otherwise drain down below the reach of plant roots, protecting the plant against drought. In the contrary, compost helps to add porosity to the clay soil, making it drain easier so that it does not stay waterlogged and does not dry out into a bricklike substance. Composts are used in agriculture to improve soil fertility and quality because they can increase organic matter content, especially in sandy soils, which have low water and nutrient holding capacity (Laila, 2009). By increasing soil organic matter content, composts can improve soil water holding capacity (Brown and Cotton, 2011).

Mohammad et al. (2004) reported that as the compost application rates were increased from 0 tons per acre to 120 tons per acre the soil moisture content were also increased (Table 1) indicating a considerable improvement in water availability. Brown and Cotton (2011) proved that soil's retentive ability correlates positively with soil organic matter content and negatively with soil density. Their result showed that the treated soil increased water holding capacity by about 1.57 times that of the control soils. Zemanek (2011) also confirmed that application of 50 t $ha^{-1}$ and 100 t. $ha^{-1}$ compost has a positive effect on soil moisture retention, regardless of possible influence of soil type, grassing and amount of rainfalls (Figure 6). However, the results of 100 t $ha^{-1}$ showed longer retention of higher values of moisture.

Noah et al. (2010) has also evaluated the effect of compost and inorganic fertilizer on water use efficiency of maize crop. The higher and significant difference that was revealed in crop water demand satisfaction under

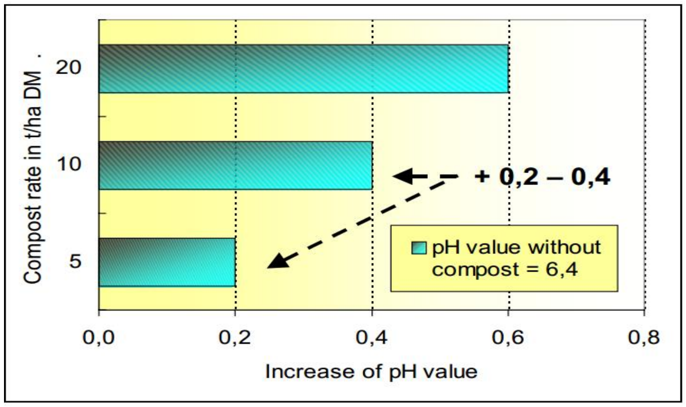



**Figure 5**: mean variation of the pH value in different soils after 8 – 11 years of compost application (kluge, 2006)

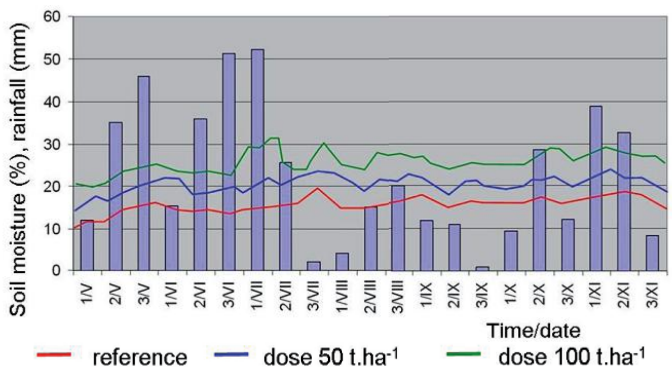



**Figure 6**. Soil moisture ratio in assessed treatments of both plots, together with course of rainfalls in 2009 and 2010 (Zemanek, 2011)

compost and its related treatment as compared to inorganic fertilizer treated soil indicate that compost media contain more available water than soil treated with inorganic fertilizer. This is because compost and its related treatments increased the organic matter content of the soil and this increased the soil available water-holding capacity (Brown and Cotton, 2011).

Regarding water use efficiency, Lalia (2009) proved that the treated sandy soil with compost led to an increase in water or fertilizers use efficiency by growing plants i.e. yield in kg per each cubic meter of irrigation water used or each unit of added nutrients. Noah et al. (2010 ) also observed that N-enriched co-compost (ECO) improved crop water use efficiency and was 11% and 4 times higher than that for NPK + $(NH_4)_2SO_4$ or soil alone.

**Effects of compost soil biological properties**

One of the most important effects of compost use is the promotion of soil biology. A great variety of organisms exists within the soil ranging from large, visible organisms to organisms, which can only be viewed under a powerful microscope. These organisms perform a wide range of functions, which are major contributions to what we consider normal and healthy soil. It might be reasonably said that these organisms have essential roles in determining the functioning of the soil system, but this functioning is dependent upon a supply of available carbon. In this context, compost has a stimulation effect on both the microbial community in the compost substrate as well as the soil-born micro biota of soils. As reported by Brown and Cotton, (2011), the application of compost has increased microbial activity in comparison to the control soils. They observed microbial activity was 2.23 times greater in the compost amended soils as compared to the control soils (Figure 7), because organic matter found in compost provides food for microorganisms.

Paul (2003) had conducted an experiment on long-term effects of manure compost and mineral fertilizers on soil biological activity and observed microbial activity was enhanced in compost treated field plots. In his trial, soil fertility was enhanced in the organic plots compared to the conventional plots as indicated by a higher microbial biomass, earthworm biomass and enhanced mycorrhizal root colonization. Microbial biomass and activity increased in the order: CONMIN < CONFYM < BIOORG < BIODYN (Figure 8). Moreover, the functional diversity of soil microorganisms and their efficiency to metabolize

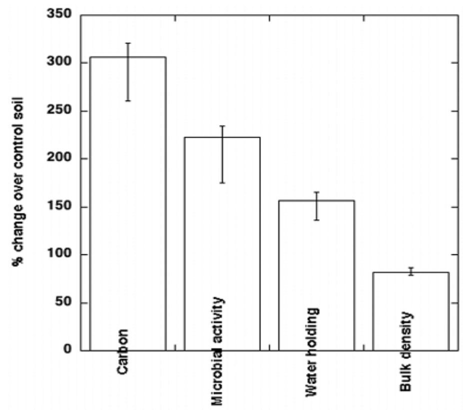
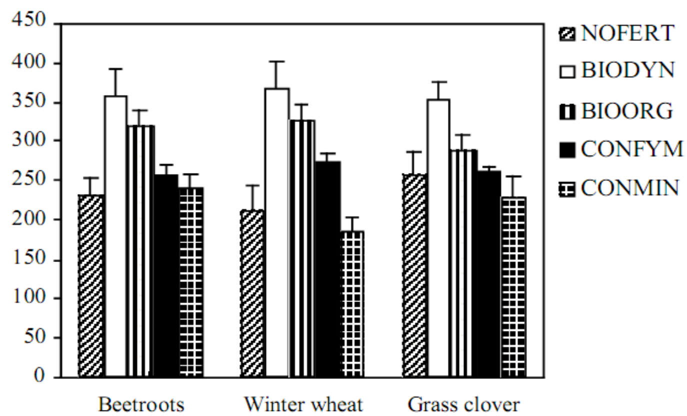



**Figure 7.** The ratio of soil organic carbon, microbial activity, water holding capacity and bulk density in compost amended soils in comparison to control soils (control soils taken from work row or other crops area with the same soil series (Brown and Cotton, 2011).




*NOFERT = unfertilized control, BIODYN = bio-dynamic (manure compost), BIOORG = bio-organic (rotted manure), CONFYM = conventional with mineral fertilizers plus manure, CONMIN = conventional without manure (exclusively mineral fertilized).*

**Figure 8.** Soil microbial biomass (mg Cmic*kg soil-1) under three crops after practicing four farming systems for three crop rotations (Paul, 2003)

organic carbon sources was increased in the organically fertilized systems with highest values in the compost manure BIODYN soils. However, two fractions of OM are responsible for the level of microbial activity in general: (i) Easily degradable organic compounds (labile OM pool) may increase microbial activity and biomass temporarily while (ii) a persistent increase of microbial biomass depends on a constant enhancement of stable OM which is particularly promoted by mature compost addition (Paul, 2003).

## Effects of compost on crop productivity

Due to its multiple positive effects on the physical, chemical and biological soil properties, compost contributes to the stabilization and increase of crop productivity and crop quality (Tayebeh et al., 2010 and

Amlinger et al., 2007). Long-term field trials proved that compost has an equalizing effect of annual/seasonal fluctuations regarding water, air and heat balance of soils, the availability of plant nutrients and thus the final crop yields (Amlinger et al., 2007). For that reason, a higher yield safety can be expected compared to pure mineral fertilization. Better crop results were often obtained if during the first years higher amounts of compost were applied every 2nd to 3rd year than by applying compost in lower quantities of < 10 Mg (DM) $ha^{-1}$ every year (Amlinger et al., 2007). However, crop yields after pure compost application were mostly lower when compared to mineral fertilization (Agegnehu et al., 2014 and Amlinger et al., 2007), at least during the first years. This can be explained by the slow release of nutrients (especially N) during mineralization of compost.

Mohammed et al. (2004) has compared the use of composted organic wastes as alternative to synthetic fertilizers for enhancing crop productivity and agricultural sustainability in two season (wet and dry). Yield results from the dry season trail showed gradual increase in crop yield as compost application rate was increased from 0 tons per acre (control) to 120 tons per acre of compost application (Figure 9). Data from the second corn harvest (fall of 2003) showed considerable yield increase (Figure 10) as the result of increased compost application rates on soils under treatment. However, 120 tons per acre of composted application rate in wet season showed decreased in yield as compared with 60 tons per acre of compost applied. This was an indication that additional application suppressed the grain production probably due to lush green vegetative growth that was observed during the growing season (Mohammed et al., 2004).

In another study, marketable yields of maize were significantly increased by 107 and 124 % due to application of compost at the rates of 5 and 7 ton $fed^{-1}$, respectively, over that of control treatment (Laila, 2011). Moreover, compost increases available form of nutrients for plant in soil and then increases root growth and nutrient uptake by plant that results in plant stem height and dry weight rise up (Soheil et al., 2012). Gamal (2009) also reported that application of 5 ton $ha^{-1}$ compost increased sorghum grain yield by 45% as compared to no compost plots, while the grain yield was higher at composted plots (10 ton $ha^{-1}$) by 19% than no compost plots in different sites.

Compost use does not only improve the growth and productivity of crops in terms of quantity but it could be also proved that quality of agricultural products is influenced in a positive way (Mehammed et al., 2012). Gemal (2009) observed that the quality of corn crop was improved as the result of increasing compost application rate. Tayebeh et al. (2010) was also observed that compost had a significant effect on seed protein and the maximum amount of seed protein was observed in 60 Mg compost $ha^{-1}$ treatment.

On the contrary, organic manures like compost discharge nutrients very slowly to the plants and these nutrients are not directly absorb by the plants. Therefore, plants are unable access required amount of nutrients in the critical yield-forming period. Hence, an integrated approach, combining application of compost with an application of inorganic fertilizer is a good strategy for increasing crop productivity. Such combination also contributed to the improvement of physical, chemical and biological properties and soil organic matter and nutrient status. Seran et al. (2010) investigated that half fold of recommended inorganic fertilizers and compost at the rate of 4 t $ha^{-1}$ could give profitable yield and this combination could possibly reduce the cost of production in the onion cultivation. Similarly, application of half the recommended N and P rate and half the recommended rate of manure and compost as inorganic N equivalence resulted in yield advantages of about 129% compared to the control (Agegnehu et al., 2014). Tayebeh et al. (2010) were also tested the effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat, and he strongly suggested using combination of organic and inorganic fertilizer to achieve highest yield without negative effect on seed quality. It is clear from the results of their study that 30% of the required nitrogen fertilizer could be replaced by compost, because compost improved the use efficiency of recommended nitrogen fertilizer and reduced its cost. In this way, by carefully managing N fertilization, less N may be needed while grain wheat yields and protein may be maintained or increased. In addition, less use of N fertilization will lead to environmental conversation.

## CONCLUSION

Intensive cultivation, misuse and excessive use of chemical fertilizers may lead to loss of soil organic matter, have adverse effects on the environment and can threaten human and animal health as well as in food safety and quality. Fertilizers are needed for high yields, particularly in nutrient poor soils. With increasing fertilizer prices and limited resources reserves, organic amendments like compost and manure as a source of nutrients and organic matter are considered an economic and environmentally-friendly alternative. Compared to plant residue and manure, composts release nutrients more slowly and have longer- lasting effects. The slow decomposition is more effective increasing soil organic matter content of the soil, which plays a key role in soil fertility by retaining nutrients, maintaining soil structure and holding water. They also have other advantages such as disposal and recycling of municipals solid wastes there by reducing material going into landfill.

Caution must also be exercised in generalizing on the

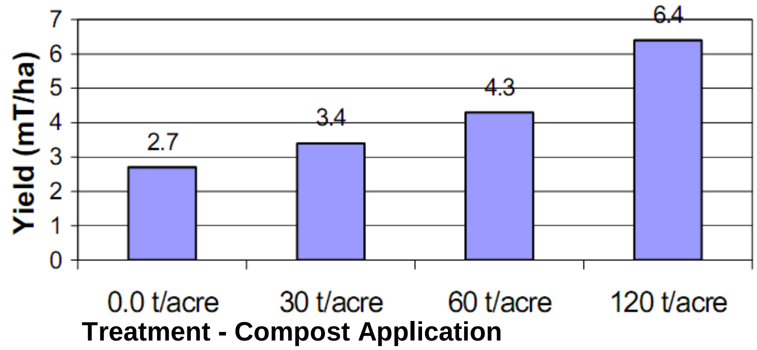



**Figure 9.**Yield results from the dry season trial (spring harvest) showing gradual increase as compost application rates were increased from 0 to 120 tons per acre (Mohammad et al., 2004).

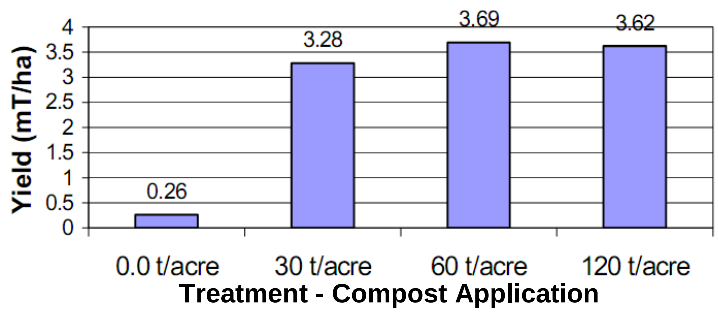



**Figure 10**. Yield results from the wet season trial (fall harvest) showing gradual increase as compost application rates were increased from 0 to 120 tons per acre (Mohammad et al., 2004).

effects of composts on soil health, fertility and crop nutrition due to the variable nature of composts, and their interactions with climatic, edaphic and crop properties. While the general effects of compost application on soils, have been well documented such as increasing soil structural stability, improving water holding capacity and plant water availability, decreasing leaching of nutrients and reducing erosion and evaporation. However, the effect of composts on soils is likely to be strongly dependent on compost composition, which depends on feedstocks, composting conditions and duration. In addition, some studies have indicated that the effects of compost application on soil and plant nutrients may be modulated by soil type. Hence, the interactions between compost type, soil properties, tillage and rotation are needed to be well characterized.

Furthermore, organic manures like compost discharge nutrients very slowly to the plants and these nutrients are not directly absorb by the plants. Therefore, plants are unable access required amount of nutrients in the critical yield-forming period. Hence, an integrated approach, combining application of compost with an application of inorganic fertilizer is a good strategy for increasing crop productivity. This will reduce the cost of inorganic fertilizer and improve soil fertility.

## REFERENCES

Agegnehu G, vanBeek C and Bird M (2014). Influence of integrated soil fertility management in wheat andtef productivity and soil chemical properties in the highland tropical environment. Journal of Soil Science and Plant Nutrition, 2014, 14

Amlinger F, Peyr S, Geszti J, Dreher P, Karlheinz W & Nortcliff S (2007). Beneficial effects of compost application on fertility and productivity of soils. Literature Study, Federal Ministry for Agriculture and Forestry, Envi. and Water Management, Austria. [Online] Available: www.umweltnet.at/filemanager/download/20558/ (Dec. 2013)

Bouajila K and Sanaa M (2011). Effects of organic amendments on soil physico-chemical and biological properties. J. Mater. Environ. Sci. 2 (S1) (2011) 485-490.

Brown S and Cotton M (2011). Changes in Soil Properties and Carbon Content Following Compost

Application: Results of On-farm Sampling. Compost Science and Utilization, (2011), Vol. 19, No. 1, 88-97.

Central Statistical Authority (2001). Population Growth and Environment in Ethiopia.

Daniel F and Bruno G (2012). Synergisms between Compost and Biochar for Sustainable Soil Amelioration, Management of Organic Waste, Dr. Sunil Kumar (Ed.), ISBN: 978-953-307-925-7. [Online] Available: http://www.intechopen.com (Sep. 2013)

Edwards S and Hailu A (2011). How to make compost and use. In: Ching L L, Edwards S and Nadia H S (Eds), Climate Change and Food Systems Resilience in Sub-Sarahan Africa. FAO, Italy. Pp: 379- 436.

Gamal Abdel-Rahman (2009). Impacts of Compost on Soil Properties and Crop Productivity in the Sahel North Burkina Faso. American- Eurasian J. Agric. and Envi. Sci, 6(2): 220 -226.

Gete Z, Getachew A, Dejene A and Shahid R ( 2010). A Report on Fertilizer and Soil Fertility Potential in Ethiopia: Constraints and opportunities for enhancing the system. IFPRI.

Kluge R (2006). Key benefits of compost use for the soil-plant system. In: Ecologically Sound Use of Biowaste in the EU; Brussels, 31 May – 1 June 2006

Laila K M Ali (2011). Significance of Applied Cellulose Polymer and Organic Manure for Ameliorating Hydro-physico-chemical Properties of Sandy Soil and Maize Yield. Australian Journal of Basic and Applied Sciences, 5(6): 23-35.

Liu B, Gumpertz M L, Hu S & Ristaino J B (2007). Long-term effects of organic and synthetic soil fertility amendments on soil microbial communities and the development of southern blight. Soil Biology and Biochemistry 39, 2302-2316.

Madeleine I, Peter S, Tim T and Tom V (2005). Agrodok no. 8: The preparation and use of cmpost. Agromisa Foundation, Wagenningen.

Mohammad H G, Denney M J and Iyekar C (2004). Use f Composted Organic Wastes as Alternative to Synthetic Fertilizers for Enhancing Crop Productivity and Agricultural Sustainability on the Tropical Island of Guam. 13th International Soil Conservation Organization Conference – Brisbane, July 2004.

Noah A, Olufunke C, K G Ofosu-Budu, J Ofosu-Animc, K B Laryea and Dionys F (2010). Effect of N-enriched co-compost on transpiration efficiency and water-use efficiency of maize (Zea mays L.) under controlled irrigation. Agricultural Water Management 97 (2010) 995–1005.

Paul M (2003). Long-term effects of manure compost and mineral fertilizers on soil biological activity as related to soil structure and crop yield. In: Amlinger F, Nortcliff S, Weinfurtner K, Dreher P, 2003c. Applying Compost – Benefits and Needs, Proc. of a seminar 22 – 23 November 2001, BMLFUW, European Commission, Vienna and Brussels.

Paulin B and Peter O`M (2008). Compost Production and Use in Horticulture. Western Australian Agri. Authority, Bulletin 4746. [Online] Available: www.agric.wa.gov.au (Nov. 2013)

Ramos M C and Marttinez-Casasnovas J A (2006). Erosion rates and nutrient losses affected by composted cattle manure application in vineyard soils of NE Spain. Catena 68 (2006)177-185.Online]Available: www.elsevier.com/locate/catena (July 2013)

Seran T H, Srikrishnah S and Ahamed M M Z (2010). Effect of different levels of inorganic fertilizers and compost as basal application on the growth and yield of onion (Allium cepa L.). The Journal of Agricultural Sciences, 2010, vol. 5, no 2: 64-70.

Soheil R, Hossien M H, Gholamreza S, Leila H, Mozhdeh J and Hassan E (2012). Effects of Composted municipal waste and its Leachate on Some Soil Chemical Properties and Corn Plant Responses. Int. Journal of Agriculture: Research and Review. Vol., 2 (6), 801-814.

Strauss P (2003). Runoff, Soil erosion and related physical properties after 7 years of compost application. In: Amlinger F, Nortcliff S, Weinfurtner K, Dreher P (2003c). Applying Compost-Benefits and Needs, Proc. of a seminar 22-23 November 2001, BMLFUW, European Commission, Vienna and Brussels. Pp. 219-224.

Tayebeh A, Abass A and Seyed A K (2010). Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. Australian Journal of Crop Science (AJCS) 4(6):384-389.

Zemanek P (2011). Evaluation of compost influence on soil water retention. Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 3, pp. 227–232.