International Journal of Agricultural Research and Review
Abbreviated Key Title: Int. J. Agric. Res Rev.
ISSN: 2360-7971 (Print) & Open Access
DOI: 10.54978/ijarr.2023. v11: 11, Pp: 105-120

Volume-11 | Issue-11 November, 20223| ***Full length Research Paper***

A Review Study on the Effect Of Selected Organic And Inorganic Fertilizers on Soil Fertility and Crop Productivity

By

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***Corresponding author: Adane A** **Accepted:** 19/11/2023 | **Published:** 14//11/2023

Abstract: Organic and inorganic fertilizers are the major categories of fertilizers used to increase agricultural productivities. Increasing organic matter content in soil, improve the soil structure, creating more air space and water retention within the soil and enhances soil nitrogen content, nutrient availability, improves nutrient mobilization. Organic fertilizer acts as a buffering agent against undesirable soil pH fluctuations. Organic fertilizers increase the quality and yield of crops. Moreover, with the use of vermicompost as organic amendments in the agriculture, recycling of the nutrients back to the soil takes place, in turn, maintaining the sustainability of the ecosystem. The advantages of vermicompost can be visualized in terms of improvement in soil physicochemical and biological properties, improved rate of nutrient uptake by crops and yield recovery as reported by many studies. Application of chemical fertilizers, like nitrogen, phosphorus, and potassium, are considered as the most beneficial way to provide nutrients to plants. The application of these fertilizers not only improves nutrients but also affects soil health either positively or negatively. For soil that much deteriorated, adding 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. Correct amount applications of inorganic fertilizer can increase soil organic matter through higher levels of root mass and crop residues. Chemical fertilizers perform valuable contribution to get high crop productivity. Therefore, in order to maintain soil fertility and promote crop productivity, the organic matter should be maintained, integrated use of organic and inorganic fertilizer should be practiced.

Keywords: Vermicompost, Inorganic fertilizer, Soil fertility, Crop productivity.

Quick Response Code

Citation **Adane A: A Review Study on the Effect Of Selected Organic And Inorganic Fertilizers on Soil Fertility and Crop Productivity**. Int. J. Res. Rev. 11(11) Pp 105-120, 2023

Journal Name
https://www.springjournals.net/

Published By IJARR

INTRODUCTION

The world population continues to increase at an alarming rate. Improvement and maintenance of soil fertility and sustaining crop production are of worldwide importance. In present day alarming situation of soil degradation and declining crop yields, sustainability in agriculture with respect to maintenance of soil fertility and stabilized crop production year after year is the main concern. To meet the increasing demand for food, intensive cultivation using more cropland areas and increased use of fertilizers had been practiced. Fertilizers are substances used to add nutrients to the soil to promote soil fertility and increase plant growth. Today fertilizer has become essential to modern agriculture to feed the growing population.

The basic purpose of fertilizer application in soil is to improve the nutrient status and quality of soil by enriching it with nutrients which it lacks. Organic and inorganic fertilizers are the major categories of fertilizers used to increase agricultural productivities. Organic fertilizer application has been reported to improve crop growth by supplying plant nutrients including both macro and micro-nutrients as well as improving soil physical, chemical, and biological properties. Increasing organic matter content in soil, improve the soil structure, creating more air space and water retention within the soil and enhances soil nitrogen content, nutrient availability, improves nutrient mobilization. Inorganic fertilizers are also referred to as mineral or chemical fertilizers. The nutrients in mineral fertilizers are relatively high, and the release of these nutrients is quick because there is no need for decomposition. Chemical fertilizers can restore the soil fertility very quickly whereas organic fertilizers will provide nutrients to the soil in slow way (Laura and Rienke, 2004).

The application of inorganic fertilizers was reported to affect the soil aggregate distribution and its associated organic carbon by increasing the aboveground and root biomass due to the immediate supply of plant nutrients in sufficient quantities (Rasool *et al.,* 2008). The use of inorganic fertilizer has been observed to cause the destruction of soil texture and structure, which often leads to soil erosion and acidity as a result of the leaching effect of nutrients. All these give rise to reduced crop yields as a result of soil degradation and nutrients imbalance (Ojeniyi, 2000). Nutrients supplied exclusively through chemical sources, though enhance yield initially, leads to unsustainable productivity over the years (Mahajan *et al.,* 2008; Satyanarayana *et al.,* 2002). Thus, the negative impacts of chemical fertilizers, have prompted the interest in the use of organic fertilizers as source of nutrients. A wide range of organic inputs are utilized. These include: composts, vermicompost, manure (FYM, green manures), crop residues, urban waste, and legumes that fix nitrogen.

The word vermicomposting is derived from the Latin word ‘Vermis’ which mean ‘worms’ (Singh, *et al.,* 2011). Vermicomposting can also be defined as a waste management technology that involves decomposition of organic fraction of solid waste in an eco-friendly way to a level that can be easily stored, handled, and applied to agricultural fields without any adverse effects (Ali *et al.*, 2015). Vermicomposting technology is a suitable tool for efficient conversion of agro-industrial processing wastes, which serves as a rich source of plant nutrients. These waste materials are packed with a tremendous source of energy, protein and nutrients, which would otherwise be lost if they are disposed as such in the open dumps and landfills. Moreover, with the use of vermicompost as organic amendments in the agriculture, recycling of the nutrients back to the soil takes place, in turn, maintaining the sustainability of the ecosystem (Garg and Gupta, 2009). Vermicompost is popularly called as black gold and has become one of the major components of organic farming system (Crescent, 2003). Nutrient recycling by use of organic manures is preferred to restore nutrient removed by crops (Jobe, 2003).

Vermicompost is particularly good for farmers, consumers and ultimately for soil as it can be used as a resource for maximizing crop productivity on sustainable basis and with more financial safe in comparison to these chemical fertilizers (Singh and Chauhan, 2009). The use of vermicompost in farms also 'sequester' huge amounts of atmospheric carbon (assimilated by green plants during photosynthesis) and bury them back into the soil improving the soil fertility, preventing erosion or compaction and also reducing greenhouse gas and mitigating global warming (Sinha *et al*., 2013). Different researches have been done on the effects of different organic and inorganic fertilizer on soil fertility as well as crop productivity. However, a current status of research on effect of organic and inorganic fertilizer is not yet reviewed well. Therefore, the objective of this review is to show the current status of research on the effects of different organic (vermicompost) and inorganic fertilizers on soil fertility and crop productivity.

LITRATURE REVIEW

Effects of Selected Organic Fertilizer on Soil Fertility and Crop Productivity

Vermicompost (product of vermicomposting) can be considered a potential replacement to agrochemical fertilizers. While agrochemical fertilizers have negative impact on the environment by increasing plant production on the cost of reducing the soil productivity (Datta *et al.,* 2016); vermicomposting produces better soil fertilizers richer in nutrients and less in chemical compounds (Lim *et al.,* 2015, Arumugam *et al.,* 2015). Vermicomposting has emerged as a sustainable technology for management of organic waste, production of organic fertilizer and reduction in use of chemical fertilizers. The key role of vermicompost is change in physical, chemical and biological properties of soil by earthworm activities and they thus called as soil managers (Ismail, 1997). These earthworm casts are rich in organic matter and have high rates of mineralization that implicates a greatly enhanced plant availability of nutrients, particularly ammonium and nitrate (Dominguez, Edwars, 2004). Previous studies revealed that vermicomposting improves nutrient status as well as biological characters of soil (Pant *et al.,* 2011) It is highly beneficial as it allows good drainage, improves water storage capacity and soil ventilation (Kim *et al.,* 2015).

Vermicompost has been reported to have favorable influence on the growth and yield parameters of several crops like paddy, sugarcane, brinjal, tomato, and okra (Ismail, 1997). Thus, vermicompost acts a soil conditioner (Albanell *et al.,*1988) and a slow-release fertilizer (Atiyeh *et al.,* 2001) that ultimately improves soil structure, soil fertility, plant growth and suppresses diseases caused by soil-borne plant pathogens, increases crop yield (Chaoui *et al.,*2002, Scheuerell *et al.,*2005, Singh *et al.,*2008). It greatly enhances crop productivity than inorganic fertilizers. The advantages of vermicompost can be visualized in terms of improvement in soil physicochemical and biological properties, improved rate of nutrient uptake by crops and yield recovery as reported by many studies.

Effect of Vermicompost on selected physico-chemical properties of soil

Vermicompost imparts positive impact on physico-chemical properties of soil. It helps to improve soil aggregation, stability, pH, EC, bulk density, water holding capacity (WHC), organic matter (OM), micro- and macro-nutrients. Vermicompost increases soil structural stability thus reducing the vulnerability of soil to calamities/disasters like erosion (Tejada *et al.,* (2009). Also, Vermicompost amendment reduces large aggregate formation in soil thus increasing aggregate stability in all aggregate size fractions. This can be explained by that organic matter application may have caused changes in the exchange complex that resulted in breakdown of larger fractions (Sari and Angin, 2016). Correspondingly, Doan *et al.,* (2015) reported reduction on leaching and runoff at highest quantity by vermicompost compared to control.

All composts including vermicompost reduce the bulk density of the soil, preventing compaction and improving potential root growth, drainage and infiltration. This also reduces ‘surface crusting and sealing’ and allows better infiltration of rainfall and irrigation. Earthworms from vermicompost keep the soil softer by their ‘burrowing and aerating actions. The greater porosity in the soil treated with vermicompost was due to an increase in the amount of rounded prose (Marinari *et al.,*2000). Pagliai *et al., (*1980) reported that the increase in porosity has been attributed to increased number of pores in the 30-50 µm and 50-500 size ranges and a decrease in number of pores greater than 500 µm.

Several studies have shown that soil amended with vermicompost are found to have significantly lower bulk density, highly porous & lighter and never compacted in terms of aeration. (Maheswarappa *et a1.,* (1999) showed significant reduced bulk density and increased porosity of soils by application of vermicompost. When vermicompost is added to soil, there is an increase in water stable aggregates, total porosity and water holding capacity (Atiyeh *et al*., 2001). Ferreras *et al*., (2006) observed that addition of 20 tons/ha of vermicompost to an agricultural soil in two consecutive years significantly improved soil porosity and aggregate stability.

A related field study by Marinari *et al*., (2000) on a soil with a 20-year conventional horticultural cropping history showed that in soil amended with vermicompost, total porosities were significantly higher than in the original soil. Hidalgo and Harkess (2002a) and Hidalgo *et al.*, (2006) reported a significant increase in total porosity and water holding capacity after addition of vermicompost to a greenhouse potting medium comprising a mixture of sand, pine bark and peat. Vermicompost is able to retain more soil moisture thus reduces the demand of water for irrigation by nearly 30 to 40%, (Suhane, 2007).

Application of Vermicompost has been found to increase soil nutrients and can be raised further by increasing rate of application. Amounts of soil N, P and K increased significantly after incorporating vermicompost into soils (Venkatesh *et al.,* 1998, Sreenivas *et al.,* 2000). Vermicompost amendment also increases micronutrients like Cu, Zn, Fe and Mn in soil at suitable concentration (Sangwan and Kaushi, 2010, Manivannan *et al.,*2009, Prabha, 2013). The addition of vermicompost in soil can also change soil pH. Atiyeh *et al*., (2001) reported that the increase of vermicompost rate in the soil resulted in the decrease in soil pH, while Maheshwarapa *et al.,* (1999) reported that the increase of the content of vermicompost decreased soil pH.

The production of NH_4^+, CO_2 and organic acids during microbial metabolism in vermicompost may be contributed to the decrease in soil pH (Albanell *et al.,*1988). Vermicompost and wood ash were reported to increase the pH of acid soils and improve soil fertility by supplying essential plant nutrients (Chaoui, 2003; Materechera, 2012). Along with this, Zeinab *et al.,* (2014) reported that Vermicompost has large particulate surface area that provides sites for the microbial activity and retention of nutrients. Similarly, Wael *et al.,* (2011) declared that Vermicompost can be used to increase the pH in acidic soils and reduce Al and Mn toxicity because of its alkalinity.

Vermicompost also has been reported to remediate metal contaminated soil. It effects concentration of heavy metal in metal contaminated soils. Angelova *et al., (*2013) reported decrease in available Zn, Cd, Cu, Mn and Pb from the soil due to Vermicompost application except Fe, while application of compost further increased Zn, Cd, Fe and Mn. This increase in heavy metal through compost was subjected to decrease in pH which make metals ions more soluble whereas reduction of heavy metals is attributed to conversion of OM to stable form by binding with the heavy metals. Thus, addition of Vermicompost in metal contaminated soil may help in soil remediation and improving its quality.

According to study conducted on Influence of vermicompost on soil chemical and physical properties in tomato (Rasool, 2008), the results showed that the total N concentration in soil was significantly (P-0.05) affected by vermicompost treatments (Table 1). The soils treated with sheep manure vermicompost at the rate of 15 t/ha had more total N compared to soils without vermicompost application. Vermicompost might have produced more residual N in soil than those in control plots. The marked decrease in total N in soils without vermicompost application in comparison with vermicompost treated soils may have been due to larger amounts of total C and N in sheep manure vermicompost that could have provided a larger source of N for mineralization (Arancon *et al.,* 2006).

There have been other reports of increase of N in soil after application of vermicompost (Nethra *et al.,* 1999). Soils treated with vermicompost at the rate of 15 t/ha had significantly more P (P-0.05) as compared to control plots (Table 1). This implied that the continuous inputs of P to the soil were probably from slow release from vermicompost and release of P was due largely to the activity of soil microorganisms (Arancon *et al.,* 2006). Marinari *et al.,* (2000) showed similar increases in soil P after application of organic amendments. In this experiment the more available P probably could have contributed to decrease of soil pH caused from application of vermicompost.

The soil available K increased significantly (P-0.05) with rising vermicompost rate (Table 1). Application of vermicompost at rate of 15, 10 and 5 t/ha increased available K in these treatments 58, 46 and 34% respectively in comparison to control plots. The results indicated that vermicompost increased Ca content of soil significantly (P-0.05). The highest increase was calculated 75 and 54% for 15 and 10 t ha^{-1} vermicompost, respectively (Table 1). Vermicompost contains most nutrients in plant available forms such as phosphates, exchangeable calcium and soluble potassium (Orozeo *et al.,* 1996). Furthermore, the results showed that the available Zn and Mn concentration in soil was significantly (P-0.05) affected by vermicompost treatments (Table 2).

Table 1: Effect of vermicompost on soil macro-elements.

Vermicompost rate(tha^{-1})	Total N (%)	P (ppm)	K (ppm)	Ca (ppm)
0	0.0700[c]	5.590[c]	379.00[c]	144.33[b]
5	0.0933[bc]	10.430[b]	523.00[b]	168.00[b]
10	0.1133[ab]	13.767[a]	555.67[b]	227.33[a]
15	0.1300[a]	18.733[a]	599.67[a]	252.67[a]

In each column means with similar letters do not significantly differ (P-0.05).

Table 2: Effect of vermicompost on soil physico-chemical and properties.

Vermicompost rate(tha^{-1})	Zn (ppm)	Cu (ppm)	Mn (ppm)	Bulk density (g cm^{-3})	Porosity (%)	PH	EC(mSc m^{-1})	OC (%)
0	2.2200	1.6000	2.4700	1.6933	35.33	8.0000	1.2970	0.624
5	2.9667	1.9033	4.1500	1.6300	37.66	7.6066	2.1183	1.001
10	3.8400	1.9833	4.9367	1.6133	38.66	7.4833	2.8967	1.254
15	4.2533	1.1400	5.7067	1.5633	40.33	7.3333	3.6700	1.323

Source, *Rasool et al., 2008*

Effect of Vermicompost on Selected Biological properties of soil

Vermicompost is a nutrient-rich, microbiologically-active organic amendment that results from the interactions between earthworms and microorganisms during the breakdown of organic matter. One of the important factors affecting fertility in the soil is the presence of organic matter in the soil and microbial activities. Vermicompost applications have been reported to increase microbial biomass concentration and phosphatase enzyme activity in soil (Sahin *et al.,* 2016). Many important factors, such as the presence of beneficial microorganisms or biologically active plant growth influencing substances such as phytohormone are released by beneficial microorganisms present in the vermicompost rich soil.

A single application of vermicompost to a strawberry crop has been shown to produce a significantly higher increase in soil microbial biomass than application of an inorganic fertilizer, independently of the dose used (Arancon *et al.,* 2006). Kale *et al.,* (1992) observed that the application of vermicompost may produce significantly greater increases in the abundance of N-fixers, actinomycetes and spore formers than in soil supplemented with inorganic fertilizers. Soil enzyme activity is also significantly increased by vermicompost addition as compared to equivalent rates of mineral fertilizers (Marinari *et al*., 2000; Arancon *et al.,* 2006).

Red worm castings contain a high percentage of humus. Humus helps soil particles form into clusters, which create channels for the passage of air and improve its capacity to hold water. Humus is believed to aid in the prevention of harmful plant pathogens, fungi, nematodes and bacteria. Vermicompost contains some antibiotics and actinomycetes that help in increasing the "power of biological resistance" among the crop plants against pest and diseases. Spray of chemical pesticides was significantly reduced by over 75% where earthworms and vermicompost were used in agriculture.

Microbial population and its activities in soil are enhanced by addition of Vermicompost. On the contrary, they are reduced in chemical amended soils (Manivannan *et al.,* 2009). Tejada *et al.,* (2009) found that Vermicompost increased soil microbial biomass and respiration by 59.1% and 69% respectively compared to control soil. Dehydrogenase, Urease, β-glucosidase, phosphatase and aryl sulfatase activities in soil was also significantly enthused with Vermicompost application compared to control. These enzyme activities were more enhanced with increasing rate of Vermicompost application. Similarly, these enzymes responsible for carbon and phosphorous cycles were found to increase with Vermicompost application during celery production in alkaline soil (Uz *et al.,* 2016).

Effect of vermicompost on crop productivity

Vermicompost increase in crop yield probably because of higher nutrient uptake (Seethalakshmi, 2011). Many researchers have testified significantly greater crop production through Vermicompost amendment. Several workers (Kale *et al.,* 1992; Tomati and Galli, 1995; Edwards and Bohlen, 1996; Ghosh *et al.,* 1999; Parthasarathi and Ranganathan, 2002; Ranganathan, 2006; Zaller, 2007; Rajesh Banu *et al*., 2008) observed that integration of vermicompost with inorganic fertilization tended to increase the yield of crop viz. tomato, potato, rapeseed, groundnut, blackgram, paddy, mulberry and marigold.

Studies made on the agronomic impacts of vermicompost on rice crops (*Oryza sativa*) reported greater population of nitrogen fixers, actinomycetes and mycorrhizal fungi inducing better nutrient uptake by crops and better growth (Kale *et al.,* 1992). Kashem *et al.,* (2015) reported higher tomato yield compared to inorganic fertilizers suggesting the significance of Vermicompost over inorganic fertilizers. Vasanthi and Kumaraswamy (1999) reported that paddy grain yields were significantly higher in plots treated with vermicompost plus NPK than in the treatment that received NPK alone. Similarly, Vasanthi and Kumaraswamy (1999) reported increased yields of rice after amending soils with vermicomposts at rates of 5t/ha or 10t/ha supplemented with recommended application rates of inorganic fertilizer.

Studies on the production of important vegetable crops like tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena)* have yielded very good results (Adhikary, 2012). Similarly, the overall productivity of potato was significantly higher on vermicompost applied about 6 tons/ha as compared to control (Adhikary, 2012). Vermicast produced higher garden pea green pod plants, higher green grain weight per plant, and higher green pod yield as compared to chemical fertilizer (Adhikary, 2012). The efficiency of vermicompost was evaluated in a field study by Desai *et al.,* (1999). They stated that the application of vermicompost along with fertilizer N gave higher dry matter (16.2 g/plant) and grain yield (3.6 t/ha) of wheat (*Triticum aestivum*) and higher dry matter yield (0.66 g/plant) of the following coriander (*Coriandrum sativum*) crop in sequential cropping system. Similarly, a positive response was obtained with the application of vermicompost to other field crops such as sorghum (*Sorghum bicolor*) (Patil and Sheelavantar 2000) and sunflower (*Helianthus annuus*) (Devi *et al.,* 1998).

A number of field experiments have reported positive effects of even low application rates of vermicompost to crops (Norman and Clive, 2005). In tomato and okra vermicompost has increased the yield effectively (Suthar, 2010). Application of vermicompost at 5 t/ha significantly increased yield of tomato (*Lycopersicon esculentum*) (5.8 t/ha) in farmers' fields in Adarsha watershed, Kothapally, Andhra Pradesh compared to control (3.5 t/ha). Tomato showed increment in yield with combined applications of vermicompost and 50% of the recommended inorganic fertilizers (Kolte *et al*., 1999). Arancon *et.al.,* (2002) reported significantly increased growth and yields of field tomatoes and peppers when vermicompost applied to field plots at rates of 20 t/ha and 10 t/ha and at rates of 10 t/ha and 5 t/ha compared with those receiving equivalent amounts of inorganic fertilizer. Ushakumari *et al*., (1999) reported that the yields of okra increased with the application vermicompost at the rate of 12 t/ha together with 100% or 75% of the recommended fertilizer.

Similarly, Athani *et al*., (1999) demonstrate that vermicompost applied at rates of 2 kg/plant together with 75% of the recommended rate of inorganic fertilizers, promoted shoot production of bananas. The yield of pea (*Pisum sativum*) was also higher with the application of vermicompost (10 t/ha) along with recommended N, P and K than with these fertilizers alone (Reddy *et al*., 1998). Vadiraj *et al*., (1998) reported that application of vermicompost produced herbage yields of coriander cultivars that were comparable to those obtained with chemical fertilizers.

A lower application rate of 2t/ha vermicompost plus recommended amounts of inorganic fertilizers, increased tomato yields to a level similar to those of tomatoes in soils treated with 4 t/ha vermicompost and 50% of the recommended rates of inorganic fertilizers (Patil *et al*., 1998). Potatoes produced the greatest marketable yields after amending the soils with 75% of the recommended inorganic fertilizers and 2.5 t/ha vermicompost (Mrinal *et al.,* 1998). Zende *et al.,* (1998) reported increased yields of sugarcane after amending soils with vermicompost at rates of 5t/ha together with 100% of the recommended application rate of inorganic fertilizers. Studies reported better yield and growth in wheat crops applied with vermicompost. Yield of wheat was improved by more than 40% by the application of vermicompost fertilizer (Palanisamy, 1996).

Effects of Selected Inorganic Fertilizer on Soil Fertility and Crop Productivity

The application of inorganic fertilizers is commonly regarded as the most dynamic method to improve soil fertility and crop productivity (Chen *et al.,* 2017). 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. Proper amount applications of inorganic fertilizer can increase soil organic matter through higher levels of root mass and crop residues (Chen, 2008, Han *et al.,*2016, GTZ, 2009), Scholl and Nieuwenhuis (2004) that mean indirectly increases organic matter. Due to this recently, farmers emphasized chemical fertilizer applications to increase productivity (Basel and Sami, 2014).

The inorganic fertilizers enhance the chemical soil properties, such as increasing the supply of macro and micro essential nutrients to meet the crop needs (Prasetyo *et al.,* 2013). Chemical fertilizers perform valuable contribution to get high crop productivity (Hepperly *et al.,* 2009). Application of chemical fertilizers, like nitrogen, phosphorus, and potassium, are considered as the most beneficial way to provide nutrients to plants. The application of these fertilizers not only improves nutrients but also affects soil health either positively or negatively. Though chemical fertilizers increase crop production; their overuse has hardened the soil, decreased fertility, strengthened pesticides, polluted air and water, and released greenhouse gases, thereby bringing hazards to human health and environment as well.

The inorganic 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 diminishing fertilizer efficiency (Alimi *et al*.,2007). Over application of chemical fertilizers can destroy decomposers and other soil organisms, reduce the colonization of plant roots with mycorrhizae and also hazardous to the soil environment (Gruhn *et al.,*20000). The over use of inorganic fertilizers can create a nutrient imbalance and that may cause soil acidity leading to low crop yields (Ojeniyi, 2002).

Effect of Inorganic Fertilizer on selected Soil Physico-chemical Properties

Soil physical properties are affected by exogenously applied chemical fertilizers. Application of chemical fertilizers increased cumulative infiltration and infiltration rate with time. Application of nitrogen fertilizer is the utmost essential tactics for improving soil physical-chemical properties (Azizi *et al.,* 2016). Nitrogen fertilizer application improved SOC concentration that results in better soil physical properties especially infiltration rate (Bhattacharyya *et al.,* 2007). A positive correlation exists between SOC and infiltration rate (Brar *et al.,* 2015; Rasool *et al.,* 2007). Phosphate fertilizer with organic matter application improves hydraulic conductivity and infiltration rate. The pores size distribution, pore continuity, and soil aggregate stability affect the value of infiltration rate (Laddha *et al.,* 1998). Phosphorus addition improves pore size and bio channels and ultimately accelerates the water flow (Haris *et al*., 2001).

Chemical fertilizer had increasing or sometimes no effect on the bulk densities of soil upon application (Malik *et al.,* 2014). For the reduction in bulk density, more soil organic carbon is required that results in higher root biomass (Bhatt *et al.,* 2019). Soil aggregation is closely related to soil bulk density. As chemical fertilizers don’t have a noticeable effect on soil aggregation and flocculation, no significant results observed on the bulk density of soil (Kumar *et al.,*2011). In contradiction, a marginal reduction is also reported in bulk density at nitrogen-phosphorus and potassium application, maybe because of improved production of biomass with the consequential upsurge in organic matter content of the soil (Bhatt *et al.,* 2019).

Other soil physical properties like soil aggregation, flocculation, infiltration rate, porosity, water holding capacity hydraulic conductivity, etc. are affected by phosphorus fertilizer application. Phosphorus addition increases rooting density, more release of exudates that increases the concentration of SOC and the associated improvement in soil structure and soil aggregation. Better soil aggregation improves soil pore continuity and porosity (Brar *et al.,* 2015). Improvement in soil aggregation happens because of precipitation of phosphate hydroxides and carbonates (Bronick and Lal, 2005).

The chemical fertility of soil determines the overall health of the soil, sustainability of crop and it is the index of availability of nutrients to plant. Soil chemical fertility is a function of various kinds of processes that occur in the soil biota. Application of chemical fertilizers, like nitrogen, phosphorus, and potassium, are considered as the most beneficial way to provide nutrients to plants. Different chemical fertilizers usually enhanced the soil nutrient available and increased nitrogen, phosphorus, and potassium available in soil (Azizi *et al.,*2016). The application of these fertilizers not only improves nutrients but also affects soil health either positively or negatively.

The over-use of chemical fertilizers can lead to soil acidification and soil crust thereby reducing organic matter content, humus content, beneficial organisms, stunting plant growth, can change the soil pH, increase pests, and even contribute to the release of greenhouse gases. The soil acidity diminishes phosphate intake by crops, increases the toxic ion concentration in the soil, and inhibits crop growth (Cooke, 1982).

The depletion of humus in the soil reduces its ability to store nutrients. Greenhouse gases derived from excess nitrogen fertilizer harm the climate. Nitrogen applied to fields in large amounts destroys the balance between the three macronutrients, N, P and K over time which would result in lack of micronutrients; it also damages topsoil, resulting in reduced crop yields. Sandy soils are much more prone to soil acidification than are clay soils. Clay soils have an ability to buffer the effects of excess chemical fertilization. Repeated applications of chemical fertilizer may result in a toxic buildup of heavy metals such as arsenic, cadmium, and uranium in the soil. These toxic heavy metals not only pollute the soil but also get accumulated in food grains, fruits and vegetables. For example, Fertilizers like Triple superphosphate has trace elements like cadmium and arsenic that accumulate in plant and through food chains reach to human that may cause health problems. The effects of chemical fertilizers on soil are great and irreversible (Sonmez and Sonmez 2007).

A large number of salts and nutrients are added in soil along with the application of inorganic fertilizer addition. An increase in salts increases salinity and electrical conductivity that ultimately increase due to addition of chemical fertilizer into a soil (Azizi *et al.,*2016). The salinity induced by N can adversely influence the nitrification process in soil, resulting in accumulation of NO_2 in the soil (Akhtar and Alam 2001). Upon applying phosphorus fertilizer, such as DAP, the concentration of soluble salts gets increased which causes salinity. Increased salinity causes inhibition of nitrification process, resulting in lesser transformation of ammonia (NH_4) to nitrate-nitrogen, therefore, an enormous amount of N was present in the form of NH_4 at the highest level of salinity (Irshad *et al.,*2018). Potassium fertilizers usually have significant effects on salinity. The application of potassium fertilizer, typically based on sulfate or chloride salts, may lead to salinization of soil because of their large salt index.

Effect of Inorganic Fertilizer on Selected Soil Biological Properties

Soil biological properties are connected with microbial activity in the soil. Soil organisms perform many functions like break down of organic matter, nutrient cycling, and making them available for plant uptake, reduce nutrient leaching loss as nutrients are stored in soil organisms' bodies, and maintain the structure of the soil. Chemical fertilizers (nitrogen phosphorus and potassium) affect microbial diversity in two ways.

The effect of chemical fertilizer depends on the type, nature, and composition of the microbial community (Rousk *et al.,* 2010). The acidophilic microbial community will be decreased when chemical fertilizers will release OH^- and increase the pH. An increase in pH will affect microbial communities adversely. While high pH will be favorable for those microbes, which are high pH loving. Chemical fertilizers that cause acidity will hinder the growth of high pH loving bacteria, while the acidophilic microbial community will flourish (Lin *et al.,* 2019). Phosphorus fertilizer hinders the growth of mycorrhizal fungi, but the extent of hindrance is dependent on fungal species and soil available Phosphorus level.

Chemical fertilizer effects on soil microbes are usually short term because soil pH changes only for a short time, and soil buffer capacity helps to attain original pH of soil. Chemical fertilizer application at different crop stages also affects the behavior of microbial communities. Flowering stage showed more microbial community compared to other stages of soil sampling. Chemical fertilization results in nutrient patches being produced, thus forming nutrient gradient in the soil that change the population of microbes (Wu *et al.,* 2012). Li *et al.,* (2013) investigated the effect of the N-gradient on nitrogen transition, microbial functional diversity, and soil microbial biomass due to chemical fertilizers such as ammonium sulfate or urea. The change with the N-gradient was observed in soil microbial biomass and microbial functional diversity.

Effect of Nitrogen(N) fertilizer on crop productivity

Plants require a number of soil nutrients like nitrogen, phosphorus and sulfur for their growth. Chemical fertilizers perform valuable contribution to get high crop productivity. Nitrogen is one of the essential macro elements needed by plants, and has a greater limiting effect on plant productivity than any other element. This is because of the fact that a large amount of N is required by plants and because of its lack of durability in the soil environment (Crawford and Glass, 1998).

Nitrogen plays a key role in agriculture by increasing crop yield. Increasing N levels increased grain yield by increasing the magnitude of yield attributes. In a study by Donner and Kucharik (Donner and Kucharik, 2003), when the application rate of nitrogen fertilizer was increased by 30%, the corn yield increased 4%, but the amount of nitrate lost through leaching increased by 53%. Nitrogen 100kg ha^{-1}produced more seed cotton yield due to a greater number of monopodial branches and sympodial branches, boll/plant, average boll weight and 100 cotton seed weight (Chen, 2019).

For sugarcane crops, nitrogen is also a backbone and improves the vegetative parts and thus increases the cane weight (Leghari *et al*., 2016). Karamity (1998) indicated that straw yield of wheat was significantly increased at the highest N level (92 kg N/ha) compared with those at lower levels. Such straw increase at higher N rates is probably due to increased plant height and tillering. According to Sorour *et al*., (1998), increased grain yield with N application resulted from an increase in one or more of the important yield components. According to Rehman *et al*. (2006), wheat plant height was significantly increased by the recommended N rate (125 kg/haN) as compared to the farmers practice (80 kg/ha N) and half of the recommended dose of N (62.5 kg/ha N). Increasing N application results in greater number of wheat spikelets per panicle (Rachon and Szumito, 2002). Since the grain size in wheat is fairly constant, sink capacity is primarily limited by spikelet number, which in turn, has a close association with N nutrition of the crop (Mugendi, *et al.,* 2000).

In another study conducted by Tilahun *et al.,* (2006), in the central and southeastern Ethiopia application of 120 kg/ha N gave the highest wheat yield of 2.84 t/ha and the straw yield raises from 24 to 29% with the raises N level from 60 to 120 kg/ha. Dwivedi and Namdeo (1992) reported increased seed yield of sesame variety, JT7 with increased nitrogen level up to 45 kg N/ha. Application of nitrogen at the rate of 210 kg/ha produced maximum maize grain yield of 2673 kg/ha which is statistically at par with 180 and 150 kg N/ha with grain yield of 2475 and 2461 kg/ha respectively and minimum grain yield of 1803 kg/ha was recorded from no application of N (Imran *et al.*, 2015). Significant response of maize grain yields up to the rate of 75 kg N/ha and 75 kg P2O5/ha in west Wollega (Tolessa *et al*., 2002), application of 184 kg/haN and 92 kg /ha P_2O_5 gave the highest grain yield (5497.5 kg/ha) in Nedjo (Geremew *et al*., 2015) and 92 kg/ha N and 69 kg/ha P_2O_5recommended for maize on Nitisols of Jimma area (Wakene *et al*., 2011). Similar work by Chiezey (2001) in the guinea savanna showed increased soybean grain yield with increased nitrogen fertilizer application from 0 to 80 kgN/ha.

Nitrogen not only enhances the yield but also improves the food quality (Leghari *et al*., 2016). The addition of N generally has the greatest effect on plant growth and a considerable influence on product quality, especially through increases in protein concentration and its quality. Various N compounds in plants are important for quality assessment. The concentration of crude protein in wheat grain may be raised from 10 percent to more than 15%, thus improving the "baking quality" of the flour. N supply increases the prolamine content in grains, thus increasing the gluten concentration of grain kernels, which improves baking quality (Rajasekar *et al*., 2017). It improves the quality of leafy vegetables and fodder and the protein content of food grains. With regard to the effect of nitrogen levels on Number of kernel per plant, Number of rows per ear and Grain yield (kg/ha), the results showed that grain yield was significantly ($P<0.05$) affected on N level from 0 to 92 kg/ha (Table 4).

Table 4*:* The effect of N fertilizer on number of kernel per plant, number of rows per ear and grain yield

N rate (kg/ha)	Number of kernels per plant	Number of rows per ear	Grain yield (kg/ha)
0	497.86	12.8	72.2
23	524.66	13.06	72.1
46	574.13	13.33	73.15
69	587.2	13.33	75.5
92	588.0	13.33	73.3
CV (%)	5.8	0.4	2.04
LSD(%)	1123	0.04	2.42

Source: *Mitiku and Asnakech (2016)*

Effect of Phosphorus (P) fertilizer on crop productivity

Phosphorus (P) is one of the major nutrients limiting agricultural production in many regions of the world and is claimed to be the second most often limiting plant nutrient. Phosphorus makes up 0.1 to 0.4% of the dry matter of the plant (FAO, 2000). By far, the greater part of P taken up by the plant is accumulated in the grain (Degeus, 1973). Plant root development, energy transfer, photosynthesis, water use efficiency, nodulation, seed formation, size and number are affected by p-availability (Tisdale *et al*., 1985; Gupta, 2011), thus affecting crop yield. It is critical for plant growth, especially in the early jointing stages and for enhancing grain yield and yield components (Ali *et al*., 2014).

In sugarcane, phosphorus is particularly important for root development, early shoot growth and tillering, maximizing early productivity, increasing internodes length and in sugarcane yield and quality. The addition of phosphorus in cotton increases the growth and yield parameters. The response of number of bolls per plant, boll weight and seed cotton yield were increased (Ahmad *et al*., 2009). According to Endalkachew (2006), increasing levels of applied P from 0 to 30 kg/ha P consistently decreased days to heading and maturity. The same author also reported application of 30 kg/ha P has significantly increased grain yield over application of 10 kg/ha P but not over 20 kg/ha P. Moreover, Asnakew *et al*., (1991) revealed that the effect of P on grain yield was highly significant with a general increase in yield as the level of P increased up to 69 kg/ha.

There are several reports that signify the role of P application in the enhancement of yield and yield components of wheat. Improvement in total number of tillers with P application might be due to the role of P in emerging radical and seminal roots during seedling establishment in wheat (Cook and Veseth, 2001). Ali *et al*., (2002) reported that application of P fertilizer in the range of 30 to 45 kg P/ha produced maximum thousand seed weight per plant, higher number of capsules, dry matter yield and seed yield of sesame. Phosphorus fertilizer on yield and yield components of barley indicated promising effect in various parts Ethiopia. Research conducted on barley at Ellala Vertisols of Northern Ethiopia depicted that yield and yield components of barley was increased with increasing P fertilizers and increment of grain yield from 740.75Kg/ha at the control plot to 1119.60Kg/ha at the rate of 20kg/ha P with 50kg/ha of Urea was observed (Fisseha ,2008).

Effect of Potassium(K) fertilizer on crop productivity

Potassium importance in plant growth and development has been known for over 150 years (Rehanul Hasan, 2002). Higher crop K requirement comes with higher crop yields. Various researches has been done on the effect of potassium fertilizer on the production of sugar beet in different parts of the world. Many of the findings indicated that potassium has significant effect on the yield and yield component of sugar beet. Research conducted in Egypt, Turkey and indicated positive response of potassium fertilization on the yield of sugar beet (Basha ,1994; Kasap and killi,1994; Nigrila *et al*.,1994). In Egypt applying potassium fertilizer at the rate of 72 kg K_2O/ha significantly enhanced yield and yield component, sucrose content and purity percentages sugar beet (Basha, 1994; EL-Shafai, 2000). Whereas according to Kasap and Killi (1994) in Turkey the highest root fresh weight/plant, root and sugar yields/ha were associated with applying potassium fertilizer at the rate of 60 kg K_2O/ha. Moreover, in Romania, application potassium fertilizer at the rate of 70 kg K_2O/ha increased root yield from 80 to 83 t/ha and sugar yield from 9.2 to 10.0 t/ha (Nigrila *et al*., (1994).

Research conducted in Pakistan on wheat - rice system on the year 2004-05 indicated that wheat showed positive response to K application. The highest increase of 50% over control in paddy yield was recorded in treatment receiving K at 60 kg K_2O/ ha (Khan *et al*., 2007). In Saudi Arabia research was conducted to see the effect of potassium fertilizer and its rate on wheat yield. The results shown the response of wheat yield is positive to the application of K rates. In India response of wheat to applied K showed increased yield even on the soils that have high level of potassium and application of 50 kg ha^{-1} of potassium sulphate (K_2SO_4) in the on-farm trial significantly increased grain and straw yields of wheat (Singh and wanjari,2012). In addition to this Uddin *et al*., (2013) indicated that the yield and yield component of NERICA1 rice variety showed significant response to the increasing rate of potassium fertilizer and the highest yield was recorded at the rate of 40 kg/ha K_2O.

CONCLUSION

Organic fertilizer application has been reported to improve crop growth by supplying plant nutrients including both macro and micro-nutrients as well as improving soil physical, chemical, and biological properties Increasing organic matter content in soil, improve the soil structure, creating more air space and water retention within the soil and enhances soil nitrogen content, nutrient availability, improves nutrient mobilization. Organic fertilizers increase the quality and yield of crops. Moreover, with the use of vermicompost as organic amendments in the agriculture, recycling of the nutrients back to the soil takes place, in turn, maintaining the sustainability of the ecosystem. The advantages of vermicompost can be visualized in terms of improvement in soil physicochemical and biological properties, improved rate of nutrient uptake by crops and yield recovery as reported by many studies.

Application of chemical fertilizers, like nitrogen, phosphorus, and potassium, are considered as the most beneficial way to provide nutrients to plants. The application of these fertilizers not only improves nutrients but also affects soil health either positively or negatively. For soil that much deteriorated, adding 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. Appropriate amount applications of inorganic fertilizer can increase soil organic matter through higher levels of root mass and crop residues.

Chemical fertilizers perform valuable contribution to get high crop productivity.

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