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Organic Fertilizer an Alternative to Chemical (Inorganic) Fertilizer for Sustainable Soil Productivity in the Era of Economic Challenges (A Review)

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Abstract

The major constraint limiting crop yield in developing countries globally and especially in the tropical Africa is soil infertility. In order to improve the fertility of the soils for maximum food production and supplies, the use of inorganic (chemical) fertilizers was adopted and used extensively. However, the scarcity and high cost of the inorganic fertilizers in recent times due to economic and global challenges like covid 19 pandemic and wars is worrisome. Also, research has shown that the continuous use of inorganic fertilizer and total dependence on it for agricultural production have led to a decline in soil fertility, land degradation and rottening of certain crops especially tubers, hence the need for an alternative. This review work studies the need of producing organic fertilizers from various organic wastes (such as agricultural waste, sewage sludge, animal waste, municipal solid waste, food waste, etc) as alternative soil amendment using the technology advancement for solid organic waste management as obtained in the developed countries. This when adopted will not only enhance and sustain soil productivity but will help to free the environment of pollution and encourage economic growth. The work also provides insight to the production line of the organic fertilizer, sources or raw materials and advantages of substituting chemical (inorganic) fertilizer with organic fertilizer. It is obvious that organic fertilizer when produced will be affordable, available, cheaper and will improve and sustain the physical, chemical and biological conditions of the soils.

Background to the Study

In tropical Africa, specifically, land degradation is a significant obstacle to agricultural productivity, and the widespread use of chemical fertilizers greatly exacerbates this issue. Due to improper fertilizer usage, which has a negative effect on agricultural soil, it results in a loss of soil fertility. There are existing limits on the use of land for agricultural cultivation due to the necessity for these areas for industrialization and development, which is a difficulty brought on by the rise in food demand due to growing populations. Due to the rising population, land has been continuously farmed year after year, resulting in a deterioration in soil fertility, such that even with the application of chemical/ inorganic fertilizer, little is obtained in return.

Chemical fertilizers and pesticides have been widely used to boost the growth and yield of crops for food production in an effort to provide the essential food supplies. According to Khosro and Yousef (2012), soil infertility is the main factor restricting crop productivity in developing countries around the world, particularly among farmers who lack access to resources. In broad areas of the world that require the fundamentals of sound farming practice, maintaining soil quality can therefore help to mitigate the issues of land degradation, decreased soil fertility, and fast declining output levels. Low crop yield is a widespread issue for most farming systems in Sub-Saharan Africa, according to Mfilinge *et al.* (2014). These low yields are pronounced in legumes and are often associated with declining soil fertility and reduced nitrogen fixation due to biological and environmental factors. Biological nitrogen fixation (BNF), a key source of nitrogen for farmers using little fertilizer, constitutes one of the potential solutions and plays a key role in sustainable production of legumes and even non legumes. . It is obvious that tropical soils are deficient in all necessary plant nutrients and large quantities of such nutrients contained in domestic wastes and agricultural by products are wasted.

Conventional agriculture plays an important role in meeting the food needs of a growing human population, which has led to an increasing dependence on the use of chemical fertilizers and pesticides for increased productivity (Bhat *et al*., 2015). Fertilizer application is vital to improve the plant characteristics and uptake of nutrients. However, the rigorous use of chemical fertilizers has led to the deterioration of the dynamic equilibrium of soil, flora and fauna ecosystems as well as water streams contamination. Chemical fertilizers are industrially made substances which are composed of known quantities of nitrogen, phosphorus and potassium. The use of chemical fertilizers causes air and ground water pollution as a result of eutrophication of water bodies (Atiyeh *et al.,* 2001). According to Chun-Li *et al*. (2014) though the practice of using chemical fertilizers and pesticides accelerates soil acidification, it also poses the risk of contaminating ground water and the atmosphere. It also weakens the roots of plants thereby making them to be susceptible to unwanted diseases (Uyovbisere and Elemo, 2000). Intensification of use of mineral fertilizer has been reported to cause soil acidity and environmental health hazard. This situation renders use of inorganic fertilizer in sustainable soil productivity counterproductive (Adepetu *et al*., 1979; Nwite *et al*., 2014).

Consequently, effort must be geared towards finding a close substitute to fertilizer that would ensure slow and steady supply of soil nutrient. Uyovbisere and Elemo (2000) reported superior effect of integrated nutrient management in increasing soil productively. Also, the potential of agricultural wastes to improve soil properties have long been recognized (Johnston,1986; Kit *et al*., 2019). Mbagwu and Ekwealo (1990) noted that combination of wastes ensured well balanced nutrients supply and uptake by crops and led to higher yield. Today, management of organic wastes generated from various sources from the environment is difficult especially in developing countries like ours. These wastes if properly processed into organic fertilizer will free the environment of pollution and sustain soil and agricultural productivity.

Objective of the Study

The objective of the review work focuses on the need to produce organic fertilizer from various organic wastes as a substitute to chemical (inorganic) fertilizer due to the high cost, scarcity and degradation of the soil by the inorganic fertilizer. The utilization of biowaste such as animal manure, sewage sludge, municipal solid waste, and food waste for biofertilizer and compost production were examined. Besides that, the advantages and drawbacks of using chemical and organic fertilizers were also examined. This work provides a comprehensive insight on the need of organic fertilizer production from biomass waste as a substitute for sustainable agricultural production.

Concept and Definition of Organic Fertilizer (Bio-Fertilizer)

Organic fertilizer or bio-fertilizer is simply a substance which contains living microorganisms which when applied to the soil, a seed or plant surface colonizes the rhizosphere and promotes growth by increasing the supply or availability of nutrients to the host plant (Raja, 2013). A bio-fertilizer is a modernized form of organic fertilizer into which beneficial microorganisms have been incorporated (Raja, 2013). According to Esmailpour *et al*. (2013) bio-fertilizer is most commonly referred to as selected strains of beneficial soil microorganisms cultured in the laboratory and packed in suitable carriers. In a large sense, the term biofertilizer may be used to include all organic resources for plant growth which are rendered in available form for plant absorption through microorganisms or plant associations or interactions (Sarkhel and Barnarjee, 2009).

In order to assure biosafety, efforts have lately been made to produce nutrient-rich, high-quality fertilizer (organic fertilizer). In order to improve soil fertility and crop productivity in sustainable farming, organic fertilizer has been discovered as a substitute for chemical fertilizer (Itelima et al., 2018). As eco-friendly and affordable inputs for farmers, these prospective biological fertilizers would be crucial to the productivity and sustainability of soil and also safeguard the environment (Sarkhel and Barnarjee, 2009). Organic farming is one of such strategies that not only ensures food safety but also adds to biodiversity of soil Silva *et al*. (2016). The application of organic fertilizer to the soil increases the biodiversity which constitutes all kinds of useful bacteria and fungi including the arbuscular mycorrhiza fungi (AMF) called plant growth promoting rhizobacteria (PGPR) and nitrogen fixers (Abdul- Halim, 2009). There are so many

microorganisms thriving in the soil, especially in the rhizosphere of plant. A considerable number of these microorganisms possess a functional relationship and constitute a holistic system with plants. They have beneficial effects on plant growth (Munnoli *et al*., 2010). Application of beneficial microorganisms in agricultural practices started about 60 years ago and it is now evident that these beneficial microbes can also enhance plant resistance to adverse environmental stresses e. g., water and nutrient deficiency and heavy metal contamination.

Through nitrogen fixation, phosphate and potassium solubilization or mineralization, release of substances that control plant growth, production of antibiotics, and biodegradation of organic matter in the soil, biofertilizers maintain a soil environment rich in all types of macro and micronutrients (Javaid, 2011). When used as soil or seed inoculants, biofertilizers multiply, take part in nutrient cycling, and increase crop productivity. Typically, 60% to 90% of the total fertilizer applied is wasted, and the remaining 10% to 40% is absorbed by plants. Therefore, biofertilizers can be a crucial part of integrated nutrient management systems for sustainable agricultural productivity and a healthy environment (Chemura, 2014). Biofertilizers are products containing living cells of different of micro-organisms which have ability to convert nutritionally important elements from unavailable to available form through biological processes (Munnoli *et al.,* 2010; Ritika and Uptal 2014).

Literature Review

This review is intended to x-ray the role of biofertilizers in sustainable agriculture thereby meeting the needs of agriculturists and plant biologists whose work focuses on creating clean and efficient means of to improving soil quality by nourishing and maintaining the useful and natural flora of microorganisms. Furthermore, it presents recent developments in the field of agricultural management that reveals the potentials of the application of biofertilizers in terms of increased nutrient profiles, plant growth and productivity and an improved tolerance to environmental stress.

The need for sustainable fertilization with minimal environmental impact has given rise to the search for alternative fertilizer sources for use in agriculture (Sarkhel and Barnarjee, 2009). So, sustainable organic farming practices can reverse the declining trends in the global productivity due to land degradation. The management of organic waste presents a challenge for developing countries as the generation of waste is increasing at a rapid and alarming rate (Adeoye *et al*., 2005; Obi *et al.,* 2016). According to one definition of organic fertilizers, these are substances with a known chemical composition and high analytical values that provide plant nutrients in a form the plants can use (Gupta, 2004). The term "organic fertilizers" refers to fertilizers made from plant, human, or animal remains (such as compost or manure). Natural ingredients are used to make organic fertilizers, which is typically related to our biodegradable wet suit. Compost is often created through the breakdown of biodegradable garbage, paper, leaves, fruit peelings from leftover meals, and even fruit juices are among these wastes. The soil benefits from the use of organic fertilizers (Sisay and Sisay, 2019). It improves the

soil's ability to support plants. Organic waste management is a global problem due to large scale urbanization, economic growth, and population explosion but can be solved by converting the waste into organic fertilizer. Environmentally, unhealthy disposal of organic wastes can degrade the environment and may cause diseases. Land filling, open dumping, and burning disposal practices are ecologically unsustainable, due to the production of certain toxic gases and leaching which can cause environmental pollution (Dube *et al*., 2014). The management of organic waste is a serious issue for the maintenance of pollution free environment. Much awareness towards the sustainability and technological advances for organic waste management has been implemented to reduce the generation of unnecessary waste (Kit *et al*.,2019). The recycling of this waste is being applied to produce valuable organic matter, which can be used as fertilizers or amendments to improve the soil structure. The addition of nitrogen fixation will enhance crop growth and avoid land degradation after long periods of agricultural activities. Phosphorus is crucial for energy metabolism, storage, and expression of genetic information (Chalmin and Gaillochet, 2009). On the other hand, potassium is essential for stimulating photosynthetic systems in plants and can improve plant growth, yield, and resistance to drought, thereby helping plants to maintain growth under stressed conditions (Pappu *et al*., 2007) This has generated increasing interest in renewable feedstock from biomass waste since the past decade.

Microbial conversion of vegetable waste to biofertilizer is a feasible and potential technology in the future to maintain the natural resources and to reduce the impact on environmental quality. It is a simple biotechnological process of composting, in which certain species of bacteria are used to enhance the process of waste conversion and produce a better end product. There are several naturally occurring microorganisms that are able to convert organic waste into valuable resources such as plant macro and micro nutrients, and reduce the C:N ratio to support soil productivity. These micro organisms are also important to maintain nutrient flows from one system to another and to minimize ecological imbalance (Silva *et al*., 2016).

Many fruits and vegetables present nearly ideal conditions for the survival and growth of many types of micro organisms. The internal tissues are nutrient rich and have a pH nearly neutral because the principal storage polymer is starch. During the composting process, various parameters including C:N ratio, composting temperature, pH of the finished product, moisture content and the presence of potential pathogens such as coliform bacteria are used to assess the quality and stability of the compost (Wu and Ma 2002; Abu- Qdais and Al-Widyan, 2016). Presently, a simple microbiological process, could provide a solution to the problem of kitchen waste disposal, and for recycling of solid waste into useful manure by the action of decomposing bacteria. Much of these biomass or organic wastes are disposed in landfills or incinerated due to the lack of space. The biomass wastes contain valuable nutrients, which can be put to good use if managed properly. They contain high organic matter and can be treated to remove pathogens and then used to fertilize soils. Unlike chemical fertilizers, organic matter requires a period of time lag to mineralize. This mineralization time will depend on the composition of the

organic matter, characteristics of soil, moisture, and temperature conditions (Ostos *et al*., 2008; Westerman and Bicudo, 2005). The soil properties will also affect the chemical reactions in the soil and can alter the dynamics of the plant nutrients intake. Besides that, the feasibility of these organic fertilizers is largely dependent on the conversion processing costs, production costs, quality of the organic fertilizers, environmental assessments, and safety to human and animal health. The use of biofertilizers will also lead to the socioeconomic and ecological improvements, especially in soil quality amendments, which will contribute tremendously to the human health and safety, food quality, and environmental preservation (Bhat *et al*., 2015).

In order to boost food production and soil fertility while reducing environmental damage, the application of these organic fertilizers and soil amendments is very promising (Atiyeh et al., 2001). By replacing mineral fertilizers with organic fertilizer, it would be possible to increase crop yields while reducing the consequences of groundwater contamination (Chemura, 2014). Furthermore, using biofertilizers can help with the bioremediation of soils that have been contaminated with hydrocarbons and pesticides. Reducing the use of high levels of chemical fertilizers, which would have a severe impact on human health and the environment, is thus a recent problem in agriculture research sectors (Silva *et al*., 2016). With the preservation of the environment and waste reduction in mind, integrated nutrient management strategies such as the combination of chemical and organic fertilizers are being developed to enhance the sustainability of crop production (Adetunji, 2005; Chen, 2006).

Source or Raw Materials for Organic Fertilizer Production

Agricultural wastes: Generally, agricultural wastes have been considered as the major source of organic fertilizer. The by-products of agricultural activities are usually referred to as "agricultural waste" because they are not the primary products. Agricultural waste or biowaste include waste such as animal manure, sewage sludge, municipal solid waste, food waste, plant and crop residues (Sartaj *et al.,* 2018). The impact of agricultural waste on the environment depends not only on the amounts generated but also on the disposal methods used. Some of the disposal practices pollute the environment. For example, agricultural waste burning is a common practice in the undeveloped countries, but it is a source of atmospheric pollution. Burning agricultural waste results in the release of pollutants such nitrous oxide, carbon (ii) oxide, and smoke carbon (Ezcurra *et al*., 2001). Ozone and nitric acid are produced together with these pollutants, which contribute to acid deposition (Lacaux *et al*., 1992) and pose a major threat to both human and ecological health. Animal waste pollution (including feces, urine, respiration and fermentation gases) is a global issue that is most acute and serious in nations with dense populations of animals and little available land for manure disposal. Animals excrete wastes in solid, liquid, and gaseous forms, and they quickly release respiration and fermentation gases into the environment (Sabiiti, 2011). After excretion, solid and liquid animal waste is subjected to microbial biomass and soluble and gaseous products. Some of these products have an impact on the environment, as well as water quality, soil deterioration and air pollution. Odour pollution among urban livestock farmers was reported to contribute highly to social tensions in kampala, Uganda Sabiiti,2011).

The raw materials or sources of organic fertilizer or bio-fertilizer were further subdivided as follows:

1. Agricultural waste: straw, rice bran, etc
2. Animal waste: chicken manure, pig, cattle and sheep manure, etc.
3. Industrial waste: vinasse, sugar residue, etc.
4. Household waste: kitchen waste, vegetable market and slaughterhouse waste, etc.
5. Municipal sludge: river silt, sewage sludge, etc. (Sartaj *et al.,* 2018).

Moreso, the application of excessive animal wastes on land as fertilizers and soil amendment is subject to surface; run-off and leaching that may contaminate ground or surface water. The aim should be to make agricultural wastes a resource that can be utilized for agricultural production. Agricultural wastes can be used to enhance food security mainly through their use as bio-fertilizer and soil amendment use as animal feed and energy production. They contain large amounts of organic matter, and many of them can be directly added to the soil without any risk. Turning these agricultural wastes (crop residue and animal manures) into organic fertilizers (through composition) is one of the waste treatment technologies that make it possible to use organic waste as a fertilizer even in populated areas (Sabiiti, 2011). Technology plays a key role in soil fertility improvement, and hence crop productivity (Javaid, 2011).

Organic Fertilizer Production Line: The organic fertilizer production line is commonly used to process different fermented organic substance into organic fertilizer or bio-fertilizer. It adopts one-step molding technology. Animal manure and agricultural waste are recycled as the main raw materials; thus, manure or dung waste is not only creating economic benefits for the enterprise, but also making a great contribution to environmental projects for mankind.

After safety disposal and fermentation, these materials are made into organic fertilizer. Thus, organic fertilizer containing a variety of organic acids, peptides, and rich nutrients including nitrogen, phosphorus and potassium. Not only provide comprehensive nutrition for crops, also with long fertilizer effect, which can increase and update the soil organic matter and promote microbial breeding, improve soil physical and chemical properties and biological activity.

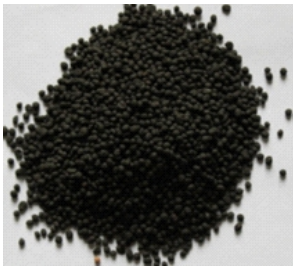

Figure 1: A sample of produced organic fertilizer
Source: fertilizer-machines.com (www.fertilizer-machines.com)

The Working Process of organic fertilizer or Bio-Fertilizer Production Line. Organic fertilizer production line is a complete set of equipment from raw materials collection to the organic fertilizer packing. The line of production is as follows:

1) Organic Materials Fermentation Process: Which plays the preliminary but indispensable role in the whole production line. Two main types of compost turner are widely used to turn and mix the compost and accelerate the fermentation speed, Self-propelled compost turner and hydraulic compost turner.
2) Crushing Process: The compost lump materials should be grinded before the granulating process. But we can leave out crushing process when the compost material is fine enough. Vertical chain crusher and double-shaft horizontal crusher, two types of crushing machine can be used to crush lump compost fertilizer raw materials.
3) Mixing Process: two types of mixing machine are applied to mix raw materials in the fertilizer production line: horizontal mixer and vertical mixer.
4) Granulator Process: Granulating process is the core part in this production line, so we choose the suitable model of fertilizer granulator according to customers detailed requirements. Disc granulator machine can be chosen to granulate the materials evenly.
5) Drying Process: When granulating, the moisture of fertilizer raw materials should be less than 25%, so we should dry the raw materials if the moisture is more than 25%. Rotary drum drying machine is mainly used for drying the fertilizer with a certain degree of humidity and particle size.
6) Rotary Drum Cooling Machine: Which is used for cooling fertilizer to make fertilizer particles stronger.
7) Rotary Drum Screening Machine: which is used to separate the granules from the large particles which need to be returned for the second crushing and granulating. Rotary drum coating machine is used to coat the fertilizer and prevent the fertilizer from sticking together.
8) The last process is packaging process: Fertilizer packaging machine can package bags quantitatively and automatically. We also need some auxiliary equipment for connection such as belt conveyor, bucket elevator, etc (Mahimaraja *et al.*, 2008).

Features of Organic Fertilizer Reproduction Line

1) The line takes animal manure and agricultural waste as its main material, not only turns the waste into treasure, but also protects the environment.
2) The whole fertilizer production process is centralized controlled, so this series of fertilizer machines are highly automatic and easy to operate.
3) Both batching system and packing system are controlled by the computer, thus ensuring the precision of material batching and fertilizer packing.
4) High-quality, stable performance, compact process layout, advanced technology, and convenient maintenance." (Itelima, Bang, Onyimba, 2018; Sabiiti, 2011).

Advantages of Organic Fertilizers

The use of organic fertilizers is particularly important in most parts of Africa, where low availability of nutrients is a serious constraint for food production (Brouwer and Powell, 2008). Composting and production of organic fertilizer from the organic wastes also reduces the volume of the waste, hence solving major environmental problems concerning disposal of large quantities waste, kills pathogens that may be present, decrease the germination of weeds in agricultural fields and reduces odour (Jakobsen, 1995). Organic fertilizer had the advantage of nutrient relationships that were more gradual than those in chemical fertilizers. This more gradual procedure prevents overfertilization, which could harm the plant (Sisay and Sisay, 2019), and enables the plant to utilize the fertilizer in a more natural manner. Additionally, the soil can be given a better airflow and drainage system. Organic fertilizers do not leak and reduce soil acidity, in contrast to chemical fertilizers. The good microbes in the soil are not wiped out by them. Aside from increasing nutrient availability, organic fertilizers also enhance the soil's structure, including air circulation that supports beneficial bacteria (Sisay and Sisay, 2019).

By utilizing more biodiversity, organic fertilizers improve soil structure and water infiltration. Organic farming is able to sequester carbon in the soil, which helps to reduce the greenhouse effect and global warming. Numerous management techniques employed in organic farming boost soil carbon uptake, boosting productivity and favoring carbon storage. For agricultural production, combinations of plants and animals optimize the cycling of nutrients and energy (Sisay and Sisay, 2019). The compost can be sold for additional revenue or used on the same farm, both crop residues and animal waste can be used as animal feed. However, the nutrient content of animal waste depends on the animal species, type of feed, and bedding material used (Mackie, 1998). The rumen contains the microbial enzyme cellulose, which is the only enzyme to digest the most abundant plant product, cellulose (Sabiiti, 2011) with ruminants, nutrients in by-products are utilized and do not become waste disposal problem (Oltjen and Beckett, 1996; Swathi, 2010). According to (Mackie *et al.*, 1998), besides generating revenue from the energy produced, waste-to energy schemes offer an alternative and environmentally acceptable means of waste disposal. Additionally, the schemes also provide a valuable by-product, a good quality, agricultural fertilizer that is nearly odourless. It is also believed that organic fertilizer if produced will be affordable, available and cheaper since the raw materials could be sourced within and not elsewhere like that of inorganic fertilizers. With the establishment of organic fertilizer plant, enough quantity will be produced and sold to the public thereby making income.

Recently in Nigeria, research interest has been diverted to use of organic wastes as source of nutrients (Uyovbisere and Elemo, 2000). This is as a result of scarcity and high cost of inorganic fertilizer. Intensification of use of mineral fertilizer has been reported to cause soil acidity and environmental health hazard. This situation renders use of inorganic fertilizer in sustainable soil productivity counterproductive (Nwite *et al.*, 2014).

Conclusion and Recommendations

The obvious decrease in soil productivity, increase in soil acidity and environmental health hazards caused by the continuous use of inorganic fertilizer as well as its scarcity and high cost have led to the demand for alternative. The growing population of the world and the need to attain food security demand more sustainable agricultural practices. To this end, organic fertilizer produced from different biowastes has been considered as an alternative due to its ability to sustain soil productivity and crop production. There is need to commercialize organic fertilizer production in tropical African using the available technology as obtainable in the developed countries. The raw materials for organic fertilizer (biofertilizer) are obtained from different biowastes and can be sourced with little or no cost with a reliable supply as these wastes are daily generated. It is believed that greater advantages will be recorded with the conversion and transformation of the organic wastes into organic fertilizers since the fertilizer produced will be readily available, affordable, cheaper, source of income and will sustain soil and crop productivity unlike the inorganic fertilizer.

It is therefore, recommended that the government at all levels should embrace the production of organic fertilizer by installing organic fertilizer plants in different agricultural zones. It is also necessary that the fertilizer when produced should be subsidized for proper utilization of every farmer.

References

Abdul- Halim, N. B. (2009). Effects of using enhanced bio-fertilizer containing N-fixer bacteria on patchouli growth. Thesis faculty of chemical and natural resources, *Engineering University Malaysia Pahang. 145*.

Abu- Qdais, H., Al-Widyan, M. (2016). Evaluating composting and co-composting kinetics of various agro-industrial wastes. *Int J Recycl Org Waste Agricult* 5:273–280

Adepetu, J. A., Obi, A. O., & Aduayi, A. (1979). Changes in soil fertility under continuous cultivation and fertilization of soil in South Western Nig, *Journal of Agric. Sc.* 1, 15-20.

Adetunji, M. T. (2005). *Integrated soil management options for Nigerian agriculture. In: Salako Adentuji, M. T. Ojanuga, A. G, Arowolo, T. and Ojeniyi, S. O. (eds). Managing soil resources for food security nd sustainable environment*, Proceedings of the 29th Annual Conf. of the Soil Sc. Soc. Of Nigeria held at University of Agric, Abeokuta, Nigeria.27-34

Atiyeh, R. M., Arancon, N., Edwards, C. A., Metzger, J. D. (2001). *The influence of earthworm processed pig manure on the growth and productivity of marigold*s, Bioresour. Technol. 81, 103–108

Bhat, S. A., Singh, J., Vig, A. P. (2015). Potential utilization of bagasse as feed material for earthworm *Eisenia fetida* and production of vermicompost. *Springer plus 4,* 11

Brouwer, J., Powell, J. M. (1998). Increasing nutrient use efficiency in West African agriculture: the impact of micro-topography on nutrient leaching from cattle and sheep manure, *Agriculture, Ecosystems and Environment*, **71**, 229-239

Chalmin, P. & Gaillochet, C. (2009). *From waste to resource, An abstract of world waste survey*. Cyclope, Veolia Environmental Services, Edition Economica, France.

Chemura, A. (2014). The growth response of coffee (Coffea arabica L) plants to organic manure, inorganic fertilizers and integrated soil fertility management under different irrigation water supply levels, *Int. J. Recycl. Org. Waste Agric. 3*, 1–9.

Chen, J. (2006). *The combined use of chemical and organic fertilizer and or bio-fertilizer for crop growth and soil fertility*, International Workshop on sustained management of the Soil-rhizosphere system for efficient crop production and fertilizer use.37-43.

Chun-Li, W., Shiuan-Yuh, C., & Chiu-Chung, Y. (2014). *Present situation and future perspective of bio-fertilizer for environmentally friendly agriculture*, Annual Reports.1-5.

Dube, R., Nandan, V., & Dua, S. (2014). Waste incineration for urban India: valuable contribution to sustainable MSWM or inappropriate high-tech solution affecting livelihoods and public health? *Int J Environ Technol Manag* 17(2/3/4), 199–214

Esmailpour, A., Hassanzadehdelouei, M., & Madani, A. (2013). Impact of livestock manure, nitrogen and Biofertilizer (Azotobacter) on Yield and Yield Components Wheat (Triticum Aestivum L.), *Agron. Res. Mold.*, *46*, 5–15.

Ezcurra, A. I., Ortiz-de, Z, Pham, V., Dhin., & Lacaux, J. P. (2001). Cereal waste burning pollution observed in the town of Vitoria (northern Spain), *Atmospheric Environment*, **35**: 1377-1386.

Gupta, P. K. (2004). *A handbook of soil, fertilizer and manure 2nd edition*.

Hegg, D. A., Radke, L. F., Hobbs, P. V., Brock, C. A., & Riggan, P. J. (1987). Nitrogen and Sulphur emissions from the burning of forest products near large urban areas, *Journal. of Geophysical Research*, 92, 14701-14709.

Itelima, J. U., Bang, W. J., & Onyimba, I. A. (2018). A review: biofertilizer; a key player in enhancing soil fertility and crop productivity, *J Microbiol Biotechnol Rep. 2*(1),22-28.

Jakobsen, S. (1995). Aerobic decomposition of organic wastes 2. Value of compost as fertilizer, *Resources, Conservation and Recycling*, 13, 57 - 71.

Javaid, A. (2011). Effects of biofertilizers combined with different soil amendments on potted rice plants, *Chil. J. Agric. Res. 71*, 157.

Johnston, A. F. (1986). *Effect of Soil organic matter on Soil use and Management,2*, 97-104.

Khosro, M., & Yousef, S. (2012). Bacterial bio-fertilizers for sustainable crop production: A review APRN, *Journal of Agricultural and Biological Science. 2012 7*(5), 237-308.

Kit, W. C., Shir, R. C., Hong-Wei. Y ., Saifuddin, N ., Yeek-Chia, H ., & Pau, L. S. (2019). *Transformation of Biomass waste into sustainable organic fertilizers. A review.*

Laboski, C. (2011). *Understanding salt index of fertilizers unpublished B.Sc. projec*t, Department of soil science University of Wisconsin-Masison. 40-64.

Lacaux, J. P., Loemba-Ndembi, J., Lefeivre, B., Cros, B., & Delmas, R. (1992). Biogenic emissions and biomass burning influences on the chemistry of the fogwater and stratiform precipitationsin the African equatorial forest, *Atmospheric Environment*, 26(A/4)541-551.

Mackie, R. I, Stroot, P. G., & Varel, V. H. (1998). Biochemical identification and biological origin of key odour components in livestock waste, *Journal of Animal. Science*, 76, 1331–1342.

Mahimaraja, S., Dooraisamy, P., & Lakshmanan, A. (2008). Composting technology and organic waste utilization. Journal of Science. 1(3), 332-560.

Mbagwu, J. S. C., & Ekwealor, G. C. (1990). Agronomic potentials of brewer's spent grain, *Biol Wast 34*, 335-347.

Mfilinge, A., Mtei, & Ndakidemi. K. (2014). Effect of Rhizobium inoculation and supplementation with phosphorus and potassium on growth leaf chlorophyll content and nitrogen fixation of bush bean varieties, *American Journal of Research Communication*. 2(10), 49-87.

Munnoli, P. M., Teixeira-da, S. J. A. & Bhosle, S. (2010). Dynamics of the soil—earthworm–plant relationship: A review, *Dyn Soil Dyn. Plant 4*, 1–21

Nwite, J. N., Okolo, C. C., Ezeaku, P. I., & Enyioko, C. (2014). Effect of integrated nutrient management on soil chemical properties and maize yield on a sandy clay loam in Abakaliki, Ebonyi State, *Inter J Agric Biosci*,3(6):278-282.

Obi, F. O., Ugwuishiwu, B. O. & Nwakaire, J. N. (2016). Agricultural waste concept, generation, utilization and management, *Nigerian Journal of Technology (NIJOTECH)*. 35(4), 957 – 964.

Ostos, J. C., Lopez-Garrido, R., Murillo, J. M., Lopez, R. (2008). Substitution of peat for municipal solid waste and sewage sludge-based composts in nursery growing media: effect on growth and nutrition of the native shrub *Pistacia lentiscus*, Bioresour, *Technol. 99*, 1793–1800.

Pappu, A., Saxena, M. & Asolekar, S. R. (2007) Solid wastes generation in India and their recycling potential in building materials, *Building Environ. 42,* 2311–2320.

Raja, N. (2013). Bipesticides and biofertilizers: ecofriendly sources for sustainable agriculture, *Journal of Biofertilizer Biopesticide*. (3), 112-15.

Rana, R, Ganguly, R. & Gupta, A. K. (2013). An assessment of solid waste management system in Chandigarh city, *India. Electron J Geotech Eng* (Bundle 6):1547–1572.

Ritika, B., & Uptal, D. (2014). Bio-fertilizer a way towards organic agriculture: A review, *Academic Journals*. 8(24), 2332-42.

Sabiiti, E. N. (2011). Utilising agricultural waste to enhance food security and conserve the environment, *African Journal of Food and Agriculture*. 11 No 6

Sarkhel, P., & Banarjee, S. (2009). Municipal solid waste management, source-seperated waste and stakeholder's attitude: a contingent valuation study, *Environ. Dev. Sustain. 12*, 611–630

Sartaj, A B., Jaswinder, S., & Adarsh, P. V. (2018). Earthworms as organic waste managers and biofertilizer producers, *Waste and Biomass, Valorization 9*, 1073–1086.

Silva, W. O., Stamford, N. P., Silva, E. V., Santos, C. E., Freitas, A. D. S., & Silva, M. V. (2016). The impact of biofertilizers with diazotrophic bacteria and fungi chitosan on melon characteristics and nutrient uptake as an alternative for conventional fertilizers, *Sci. Hortic. 209*, 236–240.

Sisay, A. S, T. (2019). The principal role of organic fertilizer on soil properties and agricultural productivity A review, *Agri Res& Tech, 22*(2), 556192. DOI: 10.19080/ ARTOAJ.2019.22.556192

Swathi, V. (2010). *The use and benefits of bio-fertilizer and biochar on agricultural soils unpublished B.Sc. thesis*, Department of Chemical and Biological Engineering. Chalmers University of Technology Goteborg Sweden. 2010, 20-24.

Uyovbisere, E. O., & Elemo, K. A. (2000). Effect of inorganic fertilizer and foliage of Azadriact and Parkia specie on the productivity of early maize, *Nig J. Soil Res, 1*, 17-2.

Westerman, P. W., & Bicudo, J. R. (2005**).** Management considerations for organic waste use in agriculture, *Bioresource Technology*, 96**,** 215 – 221.

Wu, T. Y., Lim, S. L., Lim, P. N., & Shak, K. P. Y. (2014). Biotransformation of biodegradable solid wastes into organic fertilizers using composting or/and vermicomposting, *Chem Eng Trans 39*, 1579–1584.

Youssef, M. M. A., Eissa, M. F. M. (2014). Biofertilizers and their role in management of plant parasitic nematodes: A review, *Biotechnology Pharmaceutical Resources. 5*(1), 1-6.