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Review

Values of organic materials as fertilizers to northern Nigerian crop production systems

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Organic materials, the combined products of different animal and plant sources, play vital roles in agricultural crop production systems. They are more environmental friendly than inorganic fertilizers and added many values to soil and crop production, economically. They sustain and restore soil inherent properties, enhance soil biological activities and potentially increase crop yields, which are safe for human consumption (that is, free from chemicals). This paper aims to discuss the values of organic materials as fertilizers in crop production systems of northern Nigeria. This is hoping to provide awareness for the possibility of the implementation of bioorganic fertilizers industries in northern Nigeria for permanent and economic sustainable crop production.

Key words: Organic materials, bioorganic fertilizers, crop production, Northern Nigeria.

INTRODUCTION

Agricultural soils in northern Nigeria are important areas for the production of diverse crops: Cereals (e.g. millet, sorghum, maize, rice and wheat), legumes (e.g. cowpea, ground nut and soybean), vegetables (e.g. tomato, onion), root and tubers (e.g. cassava, yam and sweet potatoes) and many others (Usman, 2007). Farmers in northern Nigeria are becoming increasingly complained about the poor soil quality, soil fertility and low crop yields due to lack of affordable and sustainable fertilizers in the region. The sprit behind healthy and high economic crop yield in farm management systems lies within the heart of organic manures applied to soils for many years in the region. However, the intensification of inorganic fertilizers in this part of Nigeria diminishes the values and economic benefits of organic materials for the last 35 years or more. This has resulted in increase soil acidity, decline soil quality, and unsustainable soil fertility managements in dryland and fadama areas of many states in the region (Bationo et al., 2003). The revitalization and/renewability of crop production under this circumstances, must readapt the traditionally old system of using only organic manures and organic materials in Nigerian cropping systems. This could help to transform our agricultural production systems into more of sustainability for significant economic developments (Wickama and Mowo, 2001; Uzoma et al., 2011; Usman, 2013).

The values and benefits of using organic materials in crop production are many. They improve and maintain soil quality, soil fertility and soil health, enhance soil water and air qualities, and potentially restore essential soil and plant nutrients (FAO, 2005; Usman, 2013). They also protect soil against erosion, runoff and mass movements,

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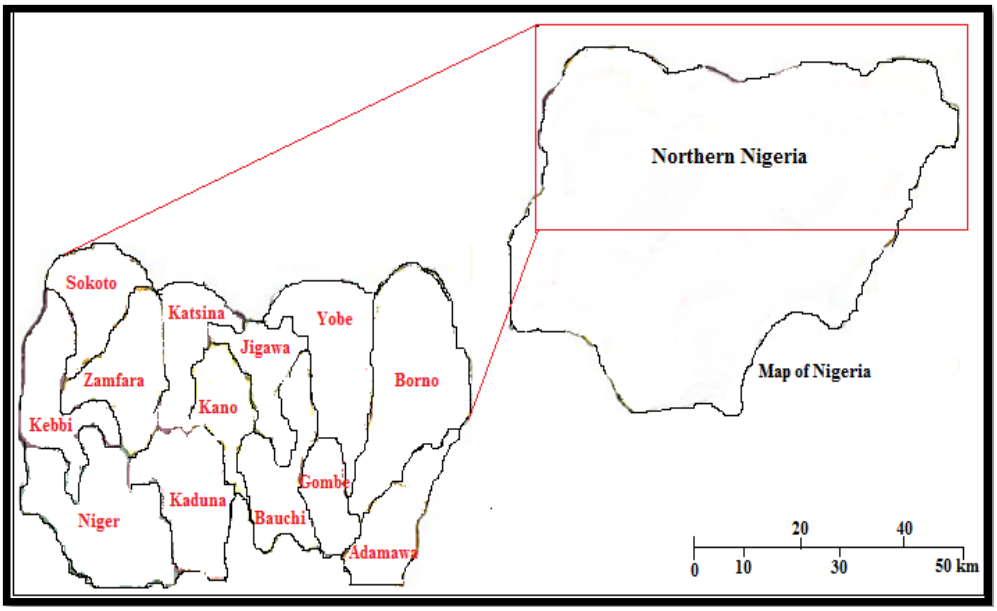

Figure 1. Geographical map of northern Nigeria.

and sustain the genetic and morphological soil properties for divers' cropping benefits (FAO, 2005; Masri and Ryan, 2006). As form of organic matter, plant and animal materials added to the soil maintains and improves soil physical quality and as such considered the most important indicator of agronomic sustainability (Reeves, 1997; Johnston, 2011). Besides, the adaptation of application of pure organic materials to soils in northern Nigeria crop production would undoubtedly leads to the development of bioorganic fertilizers industries in the region. This paper aimed to explain the values and economic benefits of organic materials as fertilizers with the possibility of the implementation of bioorganic fertilizers industries in northern Nigeria for permanent sustainable crop production.

NORTHERN NIGERIA IN A GEOGRAPHICAL CONTEXT

Northern Nigeria is a viably economic region believed to cover 75.9% of Nigeria landmass, and about 57% of this land is also believed to be under crop production or pasture (FMEN, 2001). The region lies within latitude 11° N and 14° N covering the states of Adamawa, Bauch, Borno, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Niger, Sokoto, Yobe and Zamfara (Figure 1). The two important agricultural lands recognised in these states are: dryland and fadama. The dryland area covered approximately 170,000 km^2 characterised by high sand particles, which are very low in organic matter and easily moved away by high rainfall intensity (Mortmore, 1989). On contrary, the fadama land is dominated by alluvial clay particles, which are characterised by high water holding capacity and clayed in nature (Kparmwang and Esu, 1990). The cropping systems remained the most important permanent and reliable source of income to million people living in the rural areas. The most common systems particularly in the rural areas are (Bationo et al., 2003): Millet/groundnut, millet/cowpea/sorghum, millet/cowpea and millet/sorghum. This traditional system of crop production was noted to cover 75% of the cultivated land in the tropical area of semi-arid region of Nigeria (Norman, 1974).

AVAILABLE ORGANIC MATERIALS IN NORTHERN NIGERIA

There are abundant of organic materials, which could be used for the revitalization of soils for sustainable crop production in the focus region. These organic materials are considered the most important component of crop production, and their transformation as fertilizers and compost manures remained the most vital technology in agriculture (Parr and Colacicco, 1987; Díaz et al., 2007). This technology would grants many possible ways of enhancing and maintaining agricultural soils in dryland and fadama areas of Nigeria. The organic materials consist of different source of plants, animals and varieties of dead and unwanted materials that can be easily decompose and transform into organic matter or humus (FAO, 2005). The transformation of organic matter into humus undergoes two processes, namely, mineralization and humification. Mineralization is the biochemical breakdown of dead organic materials (by soil biota) into

Table 1. Summary of the available organic materials used in northern Nigerian crop production.

Organic materials	Local name (Hausa)	Research example(s)
Animal materials: Cow dung Goat and sheep dung Donkey dung Camel dung Horse dung	Takin Dabbobi Kashin Shanu Kashin Awaki Kashin Jaki Kashin Rakumi Kashin Doki	Usman and Burt (2013): Authors tested 12 different organic materials used by farmers in northern Nigeria. Uzoma et al. (2011): Authors tested effect of cow manure on maize productivity under sandy soil condition.
Plant materials: *Acacia albida* *Acacia nilotica* *Azadirachta indica*	Takin Ganye Ganye Gawo Ganye Bagaruwa Ganyen Darbejiya	Wickama and Mowo (2001): Authors tested 8 different plant materials used by farmers in Tanzania.
Crop materials: Rice husk Millet husk Crop residues	Ganyen anfanin gona Soshiyar shinkafa Soshiyar gero Takin anfanin gona	Spaccini et al. (2002): Authors studied the influence of organic residues of some highland soils in Ethiopia.
Wood materials Wood husk Wood ash	Katako Soshiyar katako Habdi	FAO (2005): Author provided detail review of the importance of organic materials as organic matter.
Manure forms materials: Poultry manure Farmyard manure Compost manure	Takin gargajiya Takin kaji Takin gona Hadadden taki gargajiya	Parr and Colacicco (1987): Authors provided a detail review of organic materials as an alternative nutrient source of crop production in the United State.
Other materials: House refuse	Sauransu: Sharar-gida or Bolar-shara	Usman (2007): Author provided diverse ways of soil management using some organic materials in northern Nigeria.

soluble organic substances whereas humification is the change of these soluble substances into larger form (FAO, 2005). The organic matter obtained from these processes could be transform as composting, vermicomposting, bioslurry or bioorganic fertilizers. Misra et al. (2003) have provided an improved scientific on-farm composting methods, which are quite useful in the transformation of organic materials to either compost manure or bioorganic fertilizers in northern Nigeria. The most available and widely accepted organic materials in the region and their common physical properties are summarised in Tables 1 and 2, accordingly.

VALUES OF ORGANIC MATERIALS AS FERTILIZERS TO NORTHERN NIGERIA

Today, the values of organic materials as fertilizers in crop production received less concern in Nigerian crop production systems. Similarly, the appropriate use of organic matter for the management of soil quality and soil fertility was abandoned and forgotten by many households' farmers. Even with the abundant of organic materials around, there is little concern on the development of bioorganic fertilizer industry in the region. Evidences show that organic matter contains important soil nutrients (micro- and macro elements) that are more sustainable in crop production than inorganic fertilizers (FAO, 2005; Uzoma et al., 2011). In addition to macronutrients including Nitrogen (P), Phosphorus (P) and Potassium (K) which can contribute significantly to higher crop yields, there are other essential nutrients (secondary elements: Sulphur (S), Iron (Fe) and Magnesium (Mg); and micronutrients: Cupper (Cu), Boron (B), Zink (Zn), Manganese (Mn) and Molybdenum (Mo), which are presence in many organic materials (FAO, 2005). If these constituents can be substitute for essential production inputs, the values of organic materials would increase significantly in crop production (Parr and Colacicco, 1987). The development of modern bioorganic fertilizer industries could provide a permanent sustainable means of revitalizing and rehabilitating agricultural soils for healthy and high crop yield in Nigeria. There are many benefits of this including soil value, crop production value, biological value, environmental value, economic value, human health

Table 2. Common physical properties of some available organic materials in northern Nigeria (after Usman and Burt, 2013)**.**

Organic material	Colour	Consistency	Structure	Texture
Cow dung	Black	Soft-hard	Blocky (plate)	Cemetery
Sheep dung	Black	Slight-hard	Sub-angular	Gravely
Goat dung	Dark	Slight-hard	Sub-angular	Gravely
Donkey dung	Black	Soft	Blocky (round)	Cemented
Rice husk	Dark brown	Loose	Single-grain	Fine-husk
Millet husk	Light	Loose	Granular	Coarser
Acacia albida	Light brown	Loose	Massive-leafy	Fine-leafy
Acacia nilotica	Green	Loose	Massive-leafy	Fine-leafy
Wood ash	Light grey	Flowery	Massive	Ashy
Wood husk	Dark pink	Loose	Granular	Woody
House-refuse	Black-dark	Clotted	Decomposed	Clay-loam (like)

value and many others.

Soil value

Soil is the most important component of crop production and human economic interactions that we have (Brady and Weil, 2007; Usman, 2013). However, soil erosion, soil desertification and decline in soil quality and soil fertility affect most of the agricultural soils in northern Nigeria (FMEN, 2001). These soil problems, have been since recognised as serious environmental degradation that caused decline soil quality, soil fertility and crop yield in great part of sub-Saharan Africa, Asia, Europe and US (Hudson, 1981; Eswaran et al*.,* 2001; Lal et al*.,* 2003). As such, were given a special attention in 1993 at the United Nations Conference on Environment and Development (ICLDD, 2001). Conversely, the values of organic materials as organic matter were acknowledge to improved soil quality and soil fertility, suppressed soil erosion and subsequently increase crop yields in many African regions (Mango, 1999; Ramaru et al*.,* 2000; Wickama and Mowo, 2001; Gachimbi et al*.,* 2002; Usman, 2013). Besides, they were noted to increase nutrient availability of the soils, soil organic matter and soil organic carbon (Reeves, 1997; Nagaya and Lal, 2008). Application of organic matter to the soil could also improve aggregate stability and resistance to soil compaction, enhanced fertility and reduced nutrient leaching, increased biological activity, enhance water retention capacity and reduction of greenhouse gases by soil carbon sequestration (Spaccin et al*.,* 2002; Laura and DeJong-Huges, 2010). Therefore, revitalization of degraded soils for high crop yield could be cheaply minimised with the use of available organic matter in the region. This might help to restore and sustain great part of dryland and fadama soils for permanent sustainable and economic crop productions in the states of Adamawa, Bauch, Borno, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Niger, Sokoto, Yobe and Zamfara. Above and beyond, the increasing human population in these states would undoubtedly benefit much from their agricultural soils with little cost.

Crop production value

The agronomic value of organic matter applied to the soil is a subject that could be related to the increased crop yield and reduce hunger and malnutrition in Nigeria. Application of organic matter to soils would help to improve the growth and development of plant as well as yield performances (FAO, 2005). However, the crop yield response to additions of organic materials was considered to be highly variable and is dependent upon the crop type, soil type, climatic conditions, management system, and the organic materials used (Parr and Colacicco, 1987). This could mean that the crop yield performance depends greatly on these factors, and that revitalization of crop production through application of organic materials most takes note of them. Thus, reliable estimates of the economic value of organic materials in crop production depend upon the correct evaluation of agronomic information describing the crop yield response to the application of a particular organic material (Parr and Colacicco, 1987). Understanding the relationship of both single and combine organic materials with respect to their application to soil for higher crop yield performances in northern Nigeria, is highly needed (Usman and Burt, 2013). This is to ensure a permanent sustainable crop production and economic revitalization of dryland and fadama soils in the region.

Biological value

Organic materials added to the soil help to increase the activities and biodiversity of living organisms in soil and also serve as an essential source of food to million organisms in soil (FAO, 2005). During the process of

decomposition of organic materials in soil, the interaction of soil organisms with the system derives many functional services for the great biodiversity (Coleman, 2001). The decomposed organic materials on the surface soil generally results in a great biodiversity in soil environment which in turn provides protection to soil against erosion, energy source for soil biota, an effective uptake of nutrients by diverse plant roots, good rooting condition, sufficient soil moisture and perfect physical and hydric condition for plant growth (Mollison and Slay, 1991). This great biodiversity also contributes significantly to the revitalization of crop production, soil formation and soil quality rehabilitation (Jenny, 2009). The biological environment created as a result of organic materials in soil was considered to improve soil structural quality, increase aggregate stability, maintains soil moisture and improves the microbial number of soil organisms (FAO, 2005). These could help to restore and sustain great part of dryland soils, which are low in fertility and received poor management systems in northern Nigeria.

Economic value

The economic value of an organic materials added to the soil is solely related to increase crop yield (Parr and Colacicco, 1987), and absolutely related to soil fertility and soil quality management. Therefore, long term effect of organic amendment has many economic values to rural farmers (Diacono and Montemurro, 2010). This may means that the use of organic amendment in crop production by farmers could help to minimise reliance on inorganic fertilizers and hence reduce the cost of the production, increase profit and sustain better livelihood of the rural farmers in northern Nigeria. Critically, the cost implications for the use of inorganic fertilizers by farmers in many states of northern Nigeria have yielded decrease in crop production. On contrary, the application of organic materials is cheap and economically might increase the average number of farmers for the production of many vital crops in northern Nigeria. Hence, an increase in the crop productions would result in reduces hunger, malnutrition, poverty and other social crises in the whole of northern Nigeria.

Other general values

Generally, there are many other benefits of organic materials and/ bioorganic fertilizers to northern region. Some of these benefits are listed below (Usman, 2011):

1. Reduce dependence on inorganic chemical fertilizers: Available bioorganic fertilizer products in the market may reduce reliance on inorganic chemical fertilizers in northern Nigeria. Although there is need for further enlightening and awareness of the potential benefits of the products to rural farmers in the region, it is optimistic that the products would gain more acceptances as soon as the productions become fully implemented.
2. Increase yield performance: It is undoubtedly that application of organic materials and/bioorganic fertilizers to the soils would sustain soil-crop productivity and results in high crop yields in dryland and fadama areas of northern Nigeria. Although this may be affected with time by diminishing factor (Parr and Colacicco, 1987), it is believed that the shelf life of bioorganic fertilizers in soil is far higher than that of inorganic fertilizers. Bioorganic fertilizers or composting applied to the soils may last longer than inorganic fertilizers in soil.
2. Sustain and restore the inherent soil fertility of agricultural soils: The nutrients contain in the bulk of organic materials as fertilizers in soil increase the fertility of the soils. The micro and macro elements as well as aggregate stability are soil properties, which affect crop production in many ways. Application of bioorganic fertilizers in soil would enhance these properties and increase their potentialities in crop production.
3. Soil resilience against impact of raindrops: The impact of raindrops on surface soils affects soil productivity in many ways. However, presence of organic materials as litter or cover prevent surface soil against runoff, splash erosion and leaching of essential soil nutrients.
4. Seed free from chemical impact: Inorganic fertilizers, herbicides and insecticides contain chemicals, which are not good for health whereas composting and/ organic matter are free from such chemicals. Hence, the use of organic materials in crop production would yield a potential healthy seeds for human use.
5. Contribute to proper waste disposal: Physically there is urgent need of proper way of recycling and disposing unwanted dead materials in northern Nigeria. Implementation of bioorganic fertilizers and their production might help to reduce dumping of house refuse and many other unwanted organic materials on the streets. Hence, this may sanitise our environment and potentially minimise the population and impact of mosquitoes in the region.
6. Contribute to greater biodiversity: Organic materials in soil provide room for the survival of many living organisms. Addition of organic materials may increases the number of these organisms and their formation in soil.
7. Lessen environmental pollution: If organic materials are fully decompose in soil, they would help in maintaining soil health and hence minimise the soil contamination and soil hazards.
8. Environmental friendly: Organic materials are safer to environment than inorganic chemical fertilizers. They control soil contamination and soil pollution.
9. Enhance nutrient availability: Organic matter increase nutrient availability in soils and supply then to crop.
10. Preserve and sustain natural habitat: Decomposed organic materials as humus in soil preserved soil fauna

Figure 2. Example of the industrial production of bio-organic fertilizers using animal materials.

and flora, micro- and microorganism in soil.
11. Correct and maintain proper level of acidity and alkalinity in soil: Degree of acidity and alkalinity (pH) in soil may be control by addition organic materials.

IMPLEMENTATION OF BIO-ORGANIC FERTILIZERS INDUSTRIES IN NORTHERN NIGERIA

It is very clear that, the permanent sustainable soil management of agricultural soils in northern states of Nigeria is highly needed for an improvement of agricultural activities and economic developments of low input farmers, government sector and small scale holders in the region (Bationo et al*.,* 2007). Millions of people live in the rural areas of northern Nigeria and many of them depended greatly on agriculture for their daily livelihood (FMEN, 2001). One of the important economic projects that might help to improve the sustainable livelihood of these rural people is the implementation of the production of bio-organic fertilizers and compost technology (Díaz et al*.,* 2007). However, the development of bioorganic fertilizer industries in the region depends largely on the effort of the State governments to implement the projects related to the successful production of the products. It is important to mention that, northern Nigeria is one of the sub-Saharan African regions, which have considerable amount of organic materials that could be transformed into fertilizers for permanent sustainable crop production (Table 1). Thus, as one of the key goals of sound soil management to create a healthy soil environment which may retain balance nutrient status such that its fertility and high crop yield are maintained over time (Omotayo and Chukwuka, 2009), the northern states of Nigeria have the role to play in the implementation of the production of bio-organic fertilizers. These are manufactured with utmost care to ensure that they are free from all chemicals and convey longer shelf life to the rural farmers along with making crop yields safe for human consumption (Usman, 2011). The typical examples of the production industries are depicted in Figure 2 and 3 as modified after Ref 1 and Ref 2.

It is well known that the agricultural lands in the whole of northern states of Nigeria are important areas for the production of crops such as cereals (e.g. millet, sorghum, maize) and irrigated crops (e.g. rice, wheat and verities of vegetable crops such as tomato, onion etc). These agricultural lands have provided many economic opportunities to numerous people in the rural areas of Adamawa, Bauch, Borno, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Niger, Sokoto, Yobe and Zamfara states. The future agricultural economic development for healthy, high and fiscal yield performances of the agricultural lands in the region depends much on sustainable soil functions and soil quality rehabilitations through organic farming (Usman, 2007). Therefore, to ensure permanent and sustainable soil fertility functions of the agricultural lands in northern Nigeria, it is quite an important to follows example of countries such as China and India who have used the scientific knowledge and skills acquired by some of their successful researchers in the field of soil and agronomy, to transform our agricultural lands to a standard level for high crop yield and sustainable economic development in the whole of northern region. This would not only advance the standard living of millions of the rural peoples, but also

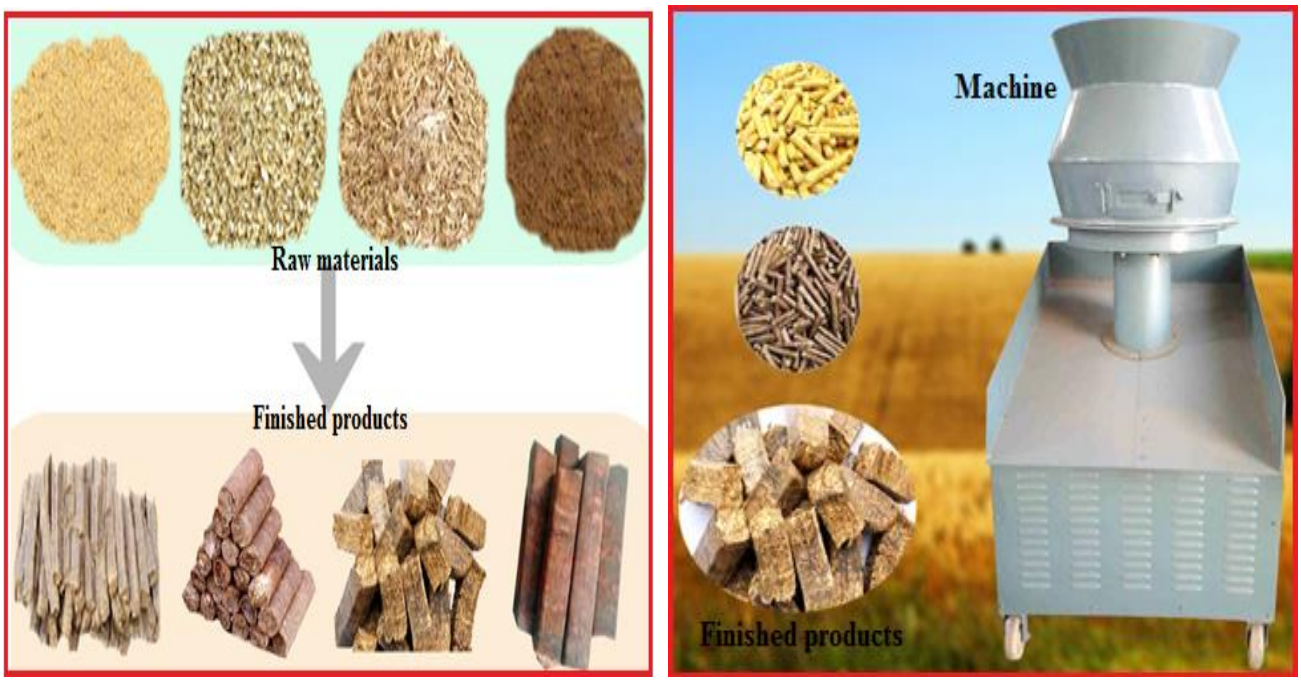

Figure 3. Example of the industrial production of bio-organic fertilizers using plant materials.

provides an opportunity for the State governments to create a self-reliance financial sector in the region and Nigeria in general.

As noted in many scientific research journals and textbooks, organic materials from plants and animals are more environmental friendly than inorganic chemical fertilizers used by farmers in the region. Consequently, the implementation of the production of bioorganic fertilizers would certainly plays an important role for the sustaining and improving soil structure, soil quality, soil function, soil health, soil fertility and overall crop yield performances in northern Nigeria. Other benefits to the entire people of the region include:

1. Government would create a permanent and sustainable economic way of self-reliance among the people of northern Nigeria
2. Government would provides job to thousands of people without any future cost (i.e. no provision of monthly salaries, pension and/ or gratitude)
3. Substantial benefits to rural people who depend fully on agriculture for their livelihood
4. Cheap fertilizer products as compared to chemical fertilizer currently marketing in the region (government could save up to 40 to 50% e.g. chemical fertilizer = N5000/bag while the organic fertilizer = N2500/bag or even less)
5. High content of NPK in organic form will reduces reliance on chemical-fertilizers
6. Increase organic carbon content of the soil to approximately 15%.
7. Improves the fertility and the productivity of the soil 100% organic without chemicals
8. Maintains a proper balance of secondary nutrients (Ca, Mg, and S) and micronutrients (Zn, Fe, Cu, Mn, B and Mo) for better plant growth
9. Helps in maintaining the soil pH and increases the plant root growth
10. Increases the microbial number and their activities/ biodiversity in soil.

CONCLUSION

The values of organic materials as fertilizers could be essential to the sustained soil-crop productivity in northern Nigeria. The revitalization of crop production in the region would be expected to yield significant results when organic materials and bioorganic fertilizers are consider the most imperative component of agricultural systems. It is optimistic that the successful implementation of bioorganic fertilizers industries in the region would certainly plays an economic role for the sustaining and improving soil structure, soil quality, soil function, soil health, soil fertility and overall crop yield performances in northern Nigeria. The relatively available organic materials in the region are resources, which may well provide many economic opportunities to the growing population in Nigeria. Management of these diverse organic resources should be consider as part of job creation, poverty reduction, environmental health administration and social youth networks under Non-

administration and social youth networks under Non-Governmental Organizations (NGOs).

Conflict of interests

The authors have not declared any conflict of interest.

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