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Evaluation of local compost methods for soil management in northwestern Nigeria: Advanced scientific theories and economic values

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Abstract

Compost technology is an advanced technology that involves the transformation of organic materials and organic waste/sludge into organic manures/fertilizers. This method was locally applied by many rural farmers in northwestern Nigeria long ago. It has been used by farmers as the best method for soil quality and soil fertility management in dryland and fadama areas of the region. This research paper was built to provide scientific advances in common compost methods in northwestern Nigeria. Approximately twelve (12) different methods were surveyed and explained based on cultural practices and scientific theories. These composting methods include dumping, hole-gathering, burning, container-packed, open-build, farm-tunnel, pond-manure, lake-fill-in, irrigated-bed-in, home-bin, farm-cattle and sheet-composting methods. These sets of methods were provided with specific instructions, fundamentals and theoretical justifications. There have been broad advances in how these methods can be used to generate revenues, create jobs, ensure safe and well-frained environments, improve food security and decrease or to some extent control the spread of malaria and other related human diseases in northwestern Nigeria. This study provides suggestions for better use of organic materials/sludge, development of bioorganic fertilizer industries, and continued revision of sustainable agricultural management with negative chemicals.

Key words: compost, compost technology, soil management, northwest

Introduction

Technology is advancing and essentially needs to be well informed, particularly of the ways that rural people in the northwest could apply it to their permanent and sustainable means of livelihood, i.e., agriculture. By adapting skills and knowledge through the natural process of recycling organic materials, more advancements can be transformed into miraculous sustainable agricultural economic development (Vigneswaran et al., 2016; Lim et al., 2017; Liu et al., 2020; Azis et al., 2022). Compost technology is an advanced technology that involves the transformation of organic materials and organic waste/sludge into organic manures/fertilizers (Usman, 2018a). Composting has been regarded as an integrated waste management technology used for the recycling of organic materials and organic wastes/sludge into the humus stage, and composting methods vary in the duration of decomposition, humification and potency of stability, maturity and sanitation (Mengistu et al., 2018). It is known as the best technology for the biological transformation of various organic materials into useful organic fertilizers (Usman, 2018a). Its scientific concept has been considered one of the best waste management practices for creating a viable environment for biota and biodiversity (Epstein, 1997; Jusoh et al., 2013).

Imagine that if all the grasses and shrubs grow in our vegetation, a house refuses that we throw away, fruit skins and rotten vegetables that we put in a bin, as well as organic waste materials that contaminate and pollute our environments, can be put together in a composite technology (Cohn, 2012; Usman, 2018a; Jalalipouret al., 2020). This will help ensure the meaningful development of technologies for local composting of various organic materials (Vázquez et al., 2020). Although some challenges have been noted regarding better waste management through composting (Ayilara et al., 2020), implementing such a possibility could make the northwest a conducive environment for everyone to visit. In addition, our agricultural soils and crops are healthier and more qualitative (Usman, 2013). This technology is wonderful, though it requires some techniques that are quite simple and easy to practice (Arrigoni et al., 2018). Careful observation is needed to ensure that the rate of decomposition increases compared with that of natural processes (Usman, 2018a; Manyapu et al., 2017). Therefore, global municipal solid waste, which is expected to increase to 3.4 billion metric tons (approximately 70%) by 2050 (Tiseo, 2018; Popp, 2020), will be utilized properly through scientific compost technology to generate a large amount of revenue, ensure a safe environment and increase food security in northwest Nigeria (Usman & Kundiri, 2016). This paper studied some of the common local composting methods in Northwest Nigeria and provided some practical advances in technology in the Northwest Zone of Nigeria as part of sustainable and renewable energy, soil quality rehabilitation and crop production systems for economic development in Nigeria.

Materials and methods

Study region

The northwestern region of Nigeria is considered the best region of the country in terms of its viable agricultural economy, especially in terms of the production of varieties of cereals and horticultural and vegetable crops (Usman, 2007). It is a region that supplies food and raw materials to many industries in the country - typically rice, maize, sorghum, pearl millet, wheat, cowpea, groundnut, tomato and other varieties of vegetables and cash crops, including edible oils, cotton, etc. For many years, the region has transformed the country's economy in many ways – development of agricultural industries, ensuring food availability, eliminating hunger and poverty, and creating agricultural research and educational institutes. The northwestern region of Nigeria is a part of 75.9% of the Nigerian landmass, 57% of which is estimated to be under crop production or pasture (FMEN, 2001). This landmass remains a vital natural resource, supporting millions of rural people through agriculture in the region. The region lies within latitudes 11°N and 14°N, covering the States of Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto and Zamfara (fig. 1). The northwestern region of Nigeria is inhibited

primarily by the Hausa and nomadic Fulani ethnic groups, the majority of which are Muslims. According to Usman (2007), the major binding factors among these people include the significance of Islamic religious culture, the language of communication and agriculture as the mainstay of economic activity, low population density, the communal nature of civil society organization and the preponderance of rural settlements within a wider context of rural poverty.

Dryland and Fadama are two agricultural lands in regions with different geo-surface soil conditions (fig. 2). The dryland area covers approximately 170,000 km2 and is characterized by high sand particles, which are very low in organic matter and are easily removed by high rainfall intensity and wind storms (Usman et al., 2016). The Fadama land is dominated by alluvial clay particles, which are characterized by a high water holding capacity and are heavy in nature (Usman, 2016). These two lands support millions of rural farmers in many ways, including through food security, ceremonial events, marriage and other sociocultural issues among citizens in the region.

Common compost materials in the study region: *Literature and field survey*

There are many important organic and inorganic materials that could be used in the production of compost fertilizers in the northwest region. Literature and field surveys in all the northwestern states were conducted, and typical examples of the most common compost materials observed are given in tables 1 and 2. These materials can be found in all the states of the northwest, although their quantity may differ. Most of these organic materials can be burned to ashes or used in a compost bin for decay (Usman & Kundiri, 2016; Usman, 2018b).

Methodology

To conduct an advanced descriptive analysis of the local methods used by farmers and other people to produce compost in northwestern Nigeria, various consultations were made with rural farmers in the region. During these consultations, a variety of interviews were used to ask farmers questions about the compost and methods involved. General discussion was based on these two topics, and relevant information was generated from farmers' inherent knowledge of compost and composting technology. However, during this discussion with farmers, the focus was only on the information needed to establish the theoretical concept of farmers' inherent knowledge of compost and the methods they used in northwestern Nigeia. Table 3 provides information about the set of activities covered during the general conversation with farmers.

Activity 1: Compost and composting (meaning): Farmers were asked about their opinions regarding the meaning of compost and composting technology. The information was used as a background for initiating activities 2, 3, 4 and 5. It was employed primarily to establish the fact that farmers are aware of the concept of compost and composting technology in the study region.

Activity 2: Composting methods (name): A discussion was made based on a simple question, i.e., what methods of composting are you practising?

Activity 3: Composting methodologies: Discussion was made based on a simple question, i.e., how can you describe the methods of composting you used?

Activity 4: Composting methods (scientific justifications): Advanced scientific theories were used based on farmers' notions of each method. In this regard, some justification was provided based on scientific improvement.

Activity 5: Compost (economic values): The discussion was based on a simple question, i.e., what do you understand to be the economic value of compost to your society?

Activity 6: Compost (economic value: scientific discussion): A scientific discussion of farmers' contributions to the economic value of compost was added.

Activity 7: General discussion: The overall description of each method of composting was made in an advanced scientific manner after careful assessment of the farmers' explanations of each activity.

Fig. 1. Map of Nigeria indicating states in the northwest

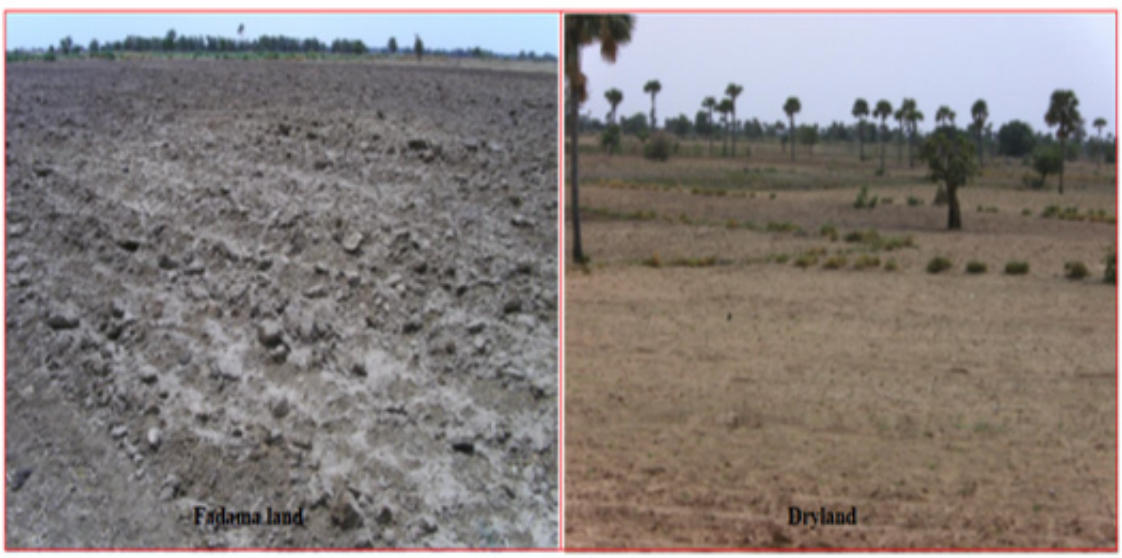

Fig. 2. Typical example of Dryland and Fadama land areas in the northwest region

Table 1. List of some available organic materials used in northwestern crop production

Organic materials	Hausa name	Research Example(s)
Animal materials:	"Takin Dabbobi"	Usman & Burt (2013): Authors tested 12 different organic materials used by farmers in Sudan Savannah Kebbi State, Nigeria.
Cow dung	"KashinShanu"	
Goat + sheep dung	"KashinAwaki"	
Donkey dung	"Kashin Jaki"	
Camel dung	"KashinRakumi"	
Horse dung	"KashinDoki"	
Plant materials:	"Takin Ganye"	Wickama & Mowo (2001): Authors tested 8 different plant materials used by farmers in Tanzania.
Acacia albida	"GanyeGawo"	
Acacia nilotica	"GanyeBagaruwa"	
Azadirachtaindica	"GanyenDarbejiya"	
Crop materials:	"Ganyengona"	Spaccini et al., (2002): Authors studied the influence of organic residues of some highland soils in Ethiopia.
Rice husk	"Soshiyarshinkafa"	
Pearl millet husk	"Soshiyargero"	
Crop residues	"Takin anfaningona"	
Wood materials:	"Burbushinkatako"	FAO (2005): Author provided detail review of the importance of organic matter.
Wood husk	"Soshiyarkatako"	
Wood ash	"Habdi"	
Manure forms:	"Takin gargajiya"	Parr & Colacicco (1987): Authors noted the detail review of organic materials as an alternative sources of nutrient of crop production in US.
Poultry manure	"Takin kaji"	
Farmyard manure	"Takin gona"	
Compost manure	"Takigargajiya"	

Discussion of the results

Table 4 provides information about the set of compost activities reported by some farmers in northwestern Nigeria. This information indicates that compost technology can be developed by considering methods that are available to local communities in northwestern Nigeria (table 4).

However, regardless of which method may be used, it should be borne in mind that good quality compost is what soil and crops need (Usman, 2018a). It has been observed that twelve (12) different methods have been used in northwestern Nigeria, and their scientific concept can be related to on-farm composting methods, which are useful in the production of compost fertilizers (Misra et al., 2003). The guidelines and procedures are believed to have followed the general concepts

Table 2. Organic/inorganic materials for compost technology (field survey)

Material	Loca name	Common in each State
Eggshells	"Kwalfarkwai"	Kano
feathers of chickens	"GashinKaji"	All the States
Leaves	"Ganyenitace"	All the States
Grass clippings	"Hakukuwa"	All the States
Papers	"Takardu"	-
Nut-shells	"Kwalfargujjiya"	Kano, Kebbi, Jigawa
Farm residues	"Karan gona"	All the States
Hays and silage	"Harawa da rauno"	All the States
Fruit peelings and cores	"Bawaryayanitace"	All the States
Unused human cloths	"TsofafinTufafi"	-
Dead animals	"Matattundabbobi"	-
Human hairs	"Gashinmutane"	All the States
House sweepings	"Sharargida"	All the States

Table 3. Activity, concept and farmers/scientific opinions

	Activity	Concept	Farmers/scientific opinions
1	Compost and composting	Meaning	Verbal discussion
2	Composting methods	Name	Local names
3	Composting methods	Methodologies	Local level
4	Composting methods	Scientific justification	Advanced technology
5	Compost	Economic values	Local opinion
6	Compost	Economic values	Scientific discussion
7	General discussion	Information generated	Farmers' opinion and scientific theories

of composting as discussed by Strauss (2009) and Usman (2011). By and large, it has been understood that science and technology are said to become more sustainable and economical if communicated according to the level of experience and skills of the local people of concern (Usman, 2018a; Azis et al., 2022). Therefore, the methods of composting observed in northwestern Nigeria (table 4), can be discussed scientifically in some memorable ways that all local farmers might be able to understand and practice without much difficulty.

Twelve methods of composting in northwest Nigeria

Twelve different methods of composting were reported in northwest Nigeria (table 4). These methods are considered improved traditional methods and can be described based on scientific theories and justifications (Usman & Kundiri, 2016). These scientific theories and justifications are noted to provide potential of producing compost in most reliable and advanced ways (Jalalipour et al., 2020). It is also believed to help improve the effectiveness of each method of composting at local level (Mengistu et al., 2018). These methods are discussed below.

1. Dumping method

This is a common practice widely used by

Table 4. Method, methodology and economic value of compost in northwest Nigeria

	Method	Methodology	Economic value
1	Dumping	Discarding and putting various organic materials in one place	Soil quality rehabilitation, environmental preservation, food security, water quality
2	Hole-gathering	Excavated area like a hole for dumping house waste	Soil quality rehabilitation, crop production, economic empowerment
3	Burning	Burning, bush burning	Soil rehabilitation, crop improvement
4	Container-packed	Dumping and discarding	Population maturity, crop improvement
5	Open-build	House refuse area unit built with a fenced	Crop improvement, income generation, food security
6	Farm-tunnel	Creations of tunnels for organic materials filling-up	Research foundation, food security
7	Pond-manure	Creations of pond-like areas where organic materials can be dumped	Population maturity, income generation
8	Lake-fill-in	Filling and layering the organic materials in a lake-like areas	Population maturity, income generation
9	Irrigated-bed-in	Formation of bed under irrigation system and layering the organic materials on the top surface soil layer	Food security, crop improvement,
10	Home-bin	Bin placement in the house where house refuse can be dumped	Environment preservation, income generation, self sufficiency
11	Farm-cattle	Keeping cattles largegly cows in a farm for a quite period of some days	Soil rehabilitation, crop improvement, food security
12	Sheet-composting	Layering the organic materials on the top surface soil	Soil rehabilitation, crop improvement, food security

farmers in many villages in the northwest region. It is an exercise habitually performed by household families within and outside the house. They choose a spare of land for dumping all kinds of house refuses, animal dung and rotten organic materials. These dumped materials begin to change under the natural process of decomposition due to factors such as annual rainfall, daily temperature, time and the load of added materials. Under these conditions, compost fertilizers are automatically produced without any cost. However, for many years, farmers have used this method to produce qualitative compost fertilizers to improve the soil fertility and soil quality of farmlands, particularly in dryland areas. Unfortunately, this method has been limited by several problems, including environmental revolutions in urban areas and plastic or leather accumulation at dumping sites. In most dumping areas, the composts produced are mixed with plastic waste, which reduces the quality of the compost and contaminates the farms. In this regard, the method may require some modifications according to the needs and requirements of the user.

The area selected for the dumping method should be well prepared by measuring the size, length and width of the space to be occupied (fig. 3). This area must be fenced with any affordable

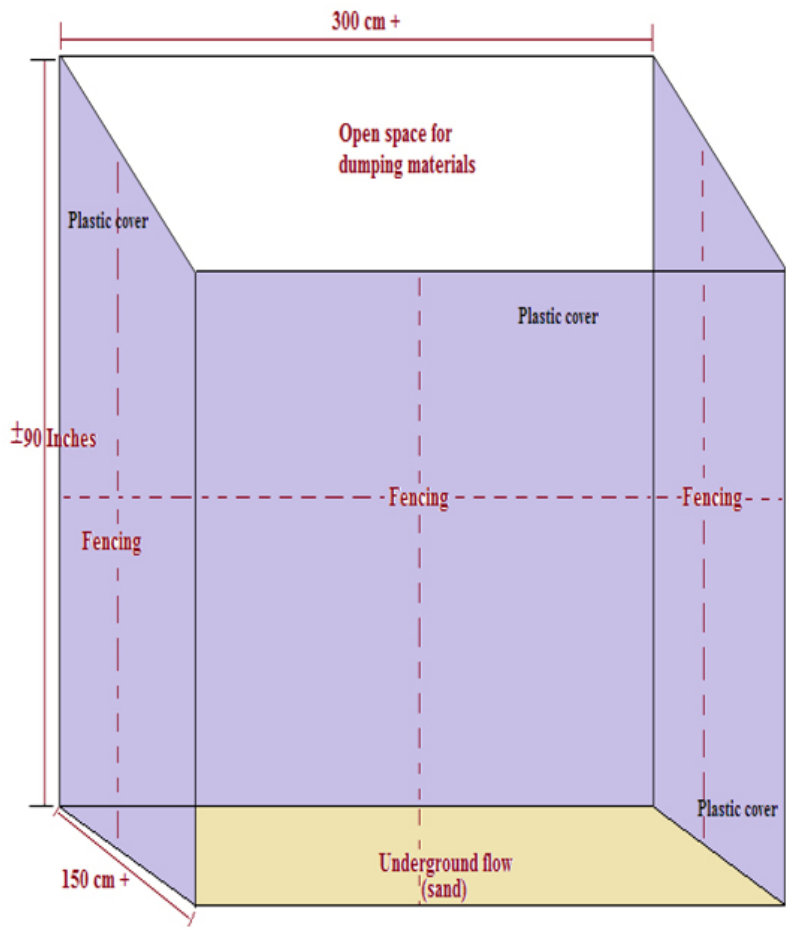

Fig. 3. Example of dumping method design

material such as plastic cover, sticks and woods or any stuff that can prevent the dumped materials from escaping the fenced area. This enables the compost to grow and decompose properly without damaging its surroundings. The following should be observed:

a. Always remove any plastic or leather before throwing materials into the dumping area.

b. The compost was inspected weekly, and any plastic leather or rubber was removed from the system.

c. The addition of water containing chemicals such as washing liquids was avoided.

d. The fencing should be opened after at least 8 to 10 days for air supply, which is useful for biota and biodiversity.

e. The materials were allowed to decompose fully and thoroughly for 4 to 6 months depending on the materials used.

f. The finished product should look dark or black or dark gray or dark brown, be very fine in texture, be crumbly, smell sweetly and be rich.

2. Hole-gathering method

This method employs the idea of digging holes for discarding materials. Farmers excavate and throw all kinds of organic materials with the aim of producing compost fertilizers. It is important to ensure that the holes are prepared according to the requirements of the user by measuring their size, length and width.

Generally, this traditional way of obtaining compost fertilizers can be improved by adhering to the following practices:

a. Only materials that are useful for soil are

used.

b. Any material that may contaminate the soil and water was removed.

c. Water was added when needed.

d. The compost was allowed to react every 3 to 4 weeks.

e. Additives such as chicken manure, wood ash, etc.

f. Limestone mixed with sand or crumbled clay particles was added.

g. The plate was covered for 2 days a week.

3. Burning method

This is a process of setting dry organic materials into fire. This method is vital for destroying materials that can take time to decompose. It is also an important source of potash in your compost. Try burning materials such as wood, grasses, shoots and shrubs, which are sometimes difficult to accompany other materials in a bin or container. The ashes were used as additives in the compost or mixed with organic matter, and the mixture was allowed to react properly.

4. Container-packed method

The container-packed method involves heaping the organic materials in a container to decompose over a long time period without any management considerations. Depending on the type of materials used, they should be allowed to remain sealed without turning or watering for up to 2 to 3 months. After this period, it should be opened, and little water should be added to increase the speed of the decomposition process and enhance the entrance of air into the container. The container was not closed for approximately 2 to 3 days. After this period, the container was closed and allowed to settle for 5 to 6 weeks before harvesting. This method can be performed by placing the container on one side of the farm or garden. Many containers can be used under this method.

5. Open-build method

This traditional method was introduced and used in many rural areas of northwestern Nigeria in the 1970s and 1980s. It is a government provision constructed as restricted areas for dumping all kinds of organic materials, house refuse and discarded items. The materials brought to these open-built areas are spread evenly regardless of whether they are good or bad for composting. The aim was to minimize environmental contamination in the town area. The materials can be layered haphazardly and are allowed to remain there for 6 to 12 months, depending on the size of the building constructed. After this time period, all the loaded materials fully decomposed and were ready for harvesting. This method requires no turning, mixing or observation. It is entirely supported by natural factors, such as annual rainfall, daily temperature, wind, humidity and the biological activities of soil biota.

The constructed area for discarding materials can be designed with an advanced scientific approach. The building should have double doors and windows at the front face. This design will help to preserve the materials and prevent them from exiting the building. Doors can be used to harvest compost whenever appropriate. The windows should be opened at the time of harvesting to minimize odours and to create an environment that is conducive for workers.

6. Farm-tunnel method

The farm-tunnel method consists of constructing tunnels on a farm that can be filled with a mixture of raw materials and buried in the soil. These tunnels can be dug to a depth of 15 cm and covered properly. If the moisture is sufficient, the materials buried in the tunnels are allowed to remain in the tunnels without turning and watering for 8 weeks. However, water should be added if the moisture is not sufficient, and this can be noted by observing the soil conditions at the surface. The moisture was checked by observing the soil at a depth of 5 cm from the surface using a hand or any appropriate means, such as a dry stick. This tunnel should be left unchecked for the next cropping season.

7. Pond-manure method

Similar to the hole-gathering method, pond manure can also be built for dumping animal dung with plant materials, which have the same shape as fish ponds. The pond should be 100 inches deep and 500 cm by 250 cm spacious. The floor of the pond area should be sandy. The materials discarded in the area can be monitored by improving the quality of the compost through mixing,

turning and moistening. Any material that cannot be decomposed easily can be burned to ashes. The fire was set in the pond to break down the organic materials. The compost was mixed thoroughly every 2 weeks, and the materials were allowed to rest for 4 to 5 months before harvesting.

8. Lake fill-in method

There are many small lake-like areas in the majority of the dryland areas of northwestern Nigeria. These areas are useful places for cattle rearing and growing rice during the dry season. They are good sources of drinking water for animals, birds and other living organisms. During the rainy season, the areas are filled with water, and this water dries out during the dry period, leaving surface areas coated with clay and silt particles. The government and individuals may use these areas for compost production when the water is about to dry out in the months of December and January. The available plant materials in the bushy savannah areas can be used to fill the lake. These materials can be used for 5 months, from January to May. Mixing, turning, watering and burning are important throughout this period. The compost was harvested in June to allow the water to accommodate the lake area for other benefits.

9. Irrigated-bed-in method

This method of composting is performed mainly on irrigated farms where beddings are designed (fig. 4). The beds should be layered with different organic materials, such as rice husk, animal dung, pearl millet husk, wood ash and wood husk. These materials should be filled layer by layer, with each layer being 10 cm thick. It is very important to maintain a timetable of turning, mixing, and watering to increase the rate of decomposition. The materials were allowed to heap and fully decompose for 3 months: November to January. After this period, the bed was cultivated, and the compost was turned upside-down before planting.

10. Home-bins method

Bins are designed for use in homes and offices for storing and recycling materials. They are important for minimizing environmental contamination. These materials are suitable and convenient for small compost production. These bins are easily filled with various organic materials, including house refuse, animal waste, kitchen scraps, fruit skins and dust. Little compost soil with some worms was added if possible. Set as many bins as possible if the house or office space is large. It is important that they be constructed with small air access doors to allow proper air circulation. Turning is also important and can be performed by using an aerating tool or garden fork.

11. Farm-cattle method

This is a traditional method of keeping cattle on a farm for a required period of time during the dry period after all the farm residues are harvested. Agreement often occurs between the farm owner and the cattle owner. It is very common in many states in the northwest. The cattle supply dung manure to the land, which can be used as a source of essential soil nutrients for the next cropping season. This method can be improved by adapting the system of turning the materials up and down at least twice during the period of cattle settlement. This may help to improve soil quality, soil health and soil function as well as the activities of soil biota on a regular basis.

12. Sheet composting method

This is another traditional method that has long been practiced by some rural farmers in northwestern Nigeria. It is a method introduced with more advanced application by the University of Florida Composting Centre (UFCC, 2023). This method involves laying organic materials on the surface soil and allowing them to decompose without further involvement. The materials are layered as top dressings covering the required land area. The recommended organic materials include wood husk, rice husk, leaves, grasses, rice straw, house refuse and animal dung. This method should be commenced immediately after harvest to permit proper decomposition of the materials applied. It is important to avoid using any material that contains weed seeds or plant pathogens. Any metal, rubber or plastic leather that cannot be destroyed in the sheet composting process should be removed. The materials added to the surface soil were well-dressed to avoid dislocation by wind or winnowing. If possible,

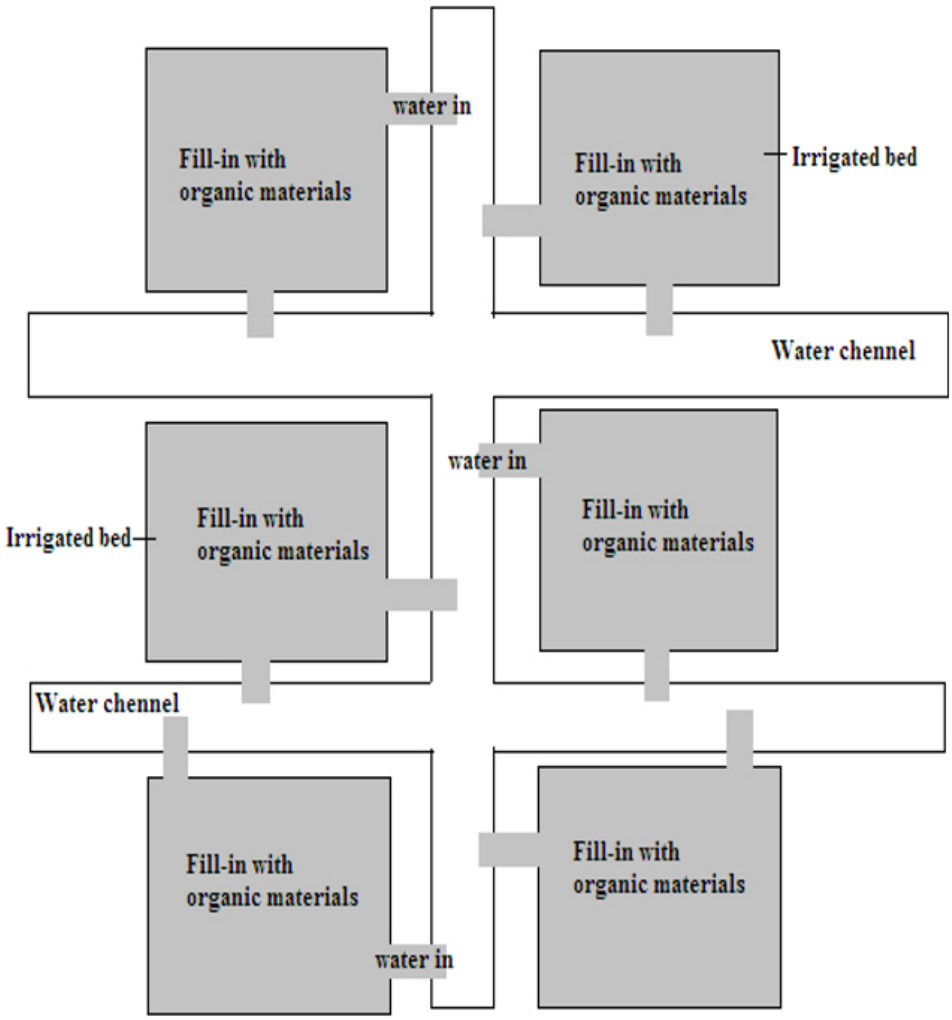

Fig. 4. Example of irrigated-bed-in method design

sand particles were used to attach the materials to the surface soil. The use of materials that can be eaten by the cattle should be avoided, as some rearing animals may move into your farm.

Economic values

Table 4 also reported different economic values of compost and composting to nothewest Nigeria. It is believed that for many years, ordinary people, who have largely depended on agriculture in a large part of sub-Saharan Africa, used a compost recycling process to produce their own exclusive fertilizers (Usman, 2018a). These fertilizers remain the only source of nutrients for soil quality and soil fertility rehabilitation in the region's crop production system (Usman, 2007). However, since 1900, the industrial revolution that has resulted in the production of mineral inorganic chemical fertilizers has changed farmers' orientation in many ways (Cabrera, 2003). They now rely entirely on chemical fertilizers and have thus become dependent on other people's technology (Usman, 2018a). This reduced the size of production because of the high cost and created many problems for soils (Usman, 2020). Farmers are, therefore, unable to feed the nation or even feed themselves. It is good that farmers

are realizing the impacts and drawbacks of using chemical fertilizers in crop production (Usman & Kundiri, 2016). This awareness may once again bring farmers to the position of turning rubbish into treasures. If this happens, the whole country will recover instantly from its constant poverty and hunger.

Generally, the northwest region needs compost technology because of its value in many aspects of human development, including soil quality and soil fertility management, environmental preservation, water quality management, crop improvement, population maturity (development), research development, economic empowerment and self-reliance (table 4). These economic values are essential for transforming the lifestyle of people in the northwestern region of Nigeria (Usman & Kundiri, 2016). The theoretical concept of these economic values, has been looked as a crutial for soil development, crop production and economic stability (Misra et al., 2003).

1. Soil quality rehabilitation: The capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation is called soil quality, as noted by USDA-NRCS (2008). The addition of compost to soil improves the soil structure, soil aggregate stability, soil colour, infiltration rate and overall soil health (Sarkar et al., 2023). These properties of soil support plants, crops and biota by adding value to soil to maintain water and nutrient availability (Usman et al., 2016). Soil feeds with compost help to prevent soil erosion and nutrient depletion (Usman, 2018b). Thus, this technology provides opportunities for many rural farmers to enhance the quality of agricultural land at little cost.

2. Soil fertility development: Healthy soil is a mother land that is expected to produce healthy crops (Usman, 2013). Therefore, any technique for supplying nutrients to the soil is vital for these crops. Fertilizers of compost release diverse nutrients to the soil: nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg) and many essential micronutrients (Usman, 2018a). This means that the technology is in a better position to minimize the use of inorganic chemical fertilizers and curtail farmers' financial burden due to its high cost.

3. Environmental preservation: If the environment is turbid, many problems are real human health impacts, soil contamination, soil pollution, water contamination and environmental hazards (Usman, 2020). However, with compost technology, much can be achieved in the northwest region. This technology can sanitize and clean our environment, eradicate mosquito populations, sieve water channels and rivers, and disinfect houses, villages, towns and cities (Liu et al., 2020). Environmental preservation can be achieved properly if northwesterners can develop a habit of self-recycling and composting waste materials disposed of on the streets.

4. Water quality management: Water quality is the physical, chemical and biological characteristics of water in relation to a set of quality standards (Macaulay Institute, 2008). The environmental water bodies in the northwest region include rivers, lakes and dams. In the rainy season, contaminated environments, waste disposal areas and chucked house refuse sites put water bodies at risk of contamination in the region. Rains move these dumped organic materials through erosion, surface runoff and permeability to contaminate water quality. Contaminated water bodies are the major cause of many human diseases (IPCC, 2023). These diseases can lead to the death of millions of children annually (WHO, 2023). Optimistically, the application of compost technology in the region could provide ways to control these health-related problems. Thus, it could serve as a means of sieving and sanitizing our water bodies and eradicating malaria, typhoid, diarrhea and cholera as well as many other related common environmental diseases in the region.

5. Crop production and improvement: Compost fertilizers increase crop production and crop health (Usman, 2020). It can serve as a way of increasing yields and maintaining seed health and quality. Compost improves soil quality, soil fertility, soil function, soil health, and biomass productivity (Lim et al., 2017). This value of compost to soils

is in many ways associated with developments in crop production and improvement. Therefore, the use of compost technology could increase crop production, the number and size of cropping lands and the population size of farmers in the northwestern region (Usman, 2018a).

6. Food security: Available and affordable food in any society is a sign of a strong economy and lovely environment (FAO, 2023). An increasing human population requires greater food availability; a shortage of food may result in hunger, malnutrition and many other social crises. According to the World Economic and Social Survey 2013, any contribution to sustainable development must focus on food security and energy transformation (DESA, 2013). The launching of compost technology in the northwest could help to promote food security, transform energy availability and eradicate hunger. Many people can enjoy a wider variety of healthy grains, fruits, vegetables, leafy plants, roots, tubers and shoots through this technology.

7. Poverty eradication: Physically and technically, poverty is real in the northwest and has been the main cause of many social crises. Under these circumstances, there is a need to renew and refurbish our economy at all levels – local, national and international. Through compost technology, crop production can be transformed within a short period and could create many jobs among young people. The vast agricultural lands in the dryland and Fadama areas could accommodate millions of youths for diverse cropping activities. With this development, governments and people may generate billions of naira as revenue annually.

8. Population maturity (developments): The population is at its peak in the northwest. Millions of people live in urban and rural areas of the region. These people must eat, drink and seek shelter. Compost technology is an artistic means of assembling people into a workable society that can benefit citizens socially, politically, culturally and economically. If northwesterners had work to do in their farms, they would not have been part of political indecency – the results of youths' lewdness, alcoholism, theft, smoking and killing or village crises. Through compost technology, everyone has work to do in his own house or farm or even on the street.

9. Research foundation: Compost technology may create opportunities for young people in academic and research environments to develop many research objectives for northwestern economic development. This research could lead to increased agricultural activities and add value to compost products and their marketing techniques among Nigeria, West Africa and other parts of the world.

10. Economic empowerment: There is a need to empower the increasing population of young people with a variety of economic technologies, one of which is composting. This technology is viable and works with resources that are available and affordable in the northwest. The government should support this technology by training its citizens on how to produce their own fertilizers through composting programmes.

11. Self-sufficiency: Compost technology makes people self-reliant. They develop skills and knowledge that can serve as raw materials for economically benefiting themselves. Every household could have its own industry that brings family members together to achieve its own social and religious happiness.

12. Income generation: Through compost technology, the government can generate billions of naira as a source of revenue. Organic agricultural produce can be exported to Europe and the US for precious money. An increase in the number of small-scale industries may in turn increase the government's tax revenue. Job availability means boosting other aspects of economic development.

Conclusion

The relevance of compost technology to common practices in northwestern Nigeria has been described in an advanced scientific manner. Improvements and justifications based on scientific principles are provided to help farmers produce high-quality compost in the region. Theories and practices were provided for practical and commercial purposes. Justifications were made for

each method within the theoretical framework of compost technology in the region. Twelve (12) different composting methods were evaluated and explained. These methods can be used for many economic purposes in northwest Nigeria. It is believed that better application of compost technology in this region of Nigeria could lead to better soil quality and soil fertility rehabilitation, income generation, food security, population maturity, and environmental preservation, among many other benefits. There are opportunities to employ composting technology to help create jobs among the growing youths in the region.

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