PERFORMANCE EVALUATION OF A LOCALLY FABRICATED MANURE SPREADER

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CERTIFICATION

This is to certify that the project work on the **determination of the performance characteristics of a locally fabricated Manure Spreader** was presented by **IDI DJIBADJE HAMISSOU** of the Agricultural Engineering department, school of Engineering and Engineering Technology, Federal University of Technology, Minna, in partial fulfillment of the requirement for the award of the Bachelor of Engineering (B. Eng) degree in Agricultural Engineering.

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DEDICATION

· This project work is dedicated to the most high **ALLAH** and to my father Mr. IDI DJIBADJE.

ACKNOWLEDGEMENT

My gratitude to god almighty ALLAH, the most excellent and the most merciful for preserving and sustaining my life till now and for giving me privilege, guidance and protection throughout the duration of my studies.

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ABSTRACT

The project work " performance evaluation of a locally fabricated manure spreader", Started with the processing of organic manure by composting for a period of six weeks. For reasons of comparison, 3 different categories of compost were made with the same amount of mixture each. Using pit method with mixed layers arrangement made the first compost. The second, with the same pit method with separate layers arrangement, and the last one was obtained by using heap method. Moisture contents after four weeks of decomposition and means of weekly temperatures for the first, second and third composts were recorded and given as 45.38%, 40.52%, 37.95% and 53.66°C , 50°C , 39.66°C respectively. These values showed that the first compost was the best and therefore was used for testing the spreader. Its bulk density was determined as $793.64kg/m^3$.

The machine was tested for rate of application, field capacity and the time rate of handling manure with values of 4.95t/ha, 0.467ha/hr and 2.35t/hr, respectively. It is recommended that further work should be under taken to improve on its performance especially the size of the storage unit of the spreader should be increased. Because the machine has to be loaded about 19 times before covering one hectare. It has to be enlarged for about six times to cover the minimum requirement of spreaders.

CHAPTER ONE

INTRODUCTION

An essential feature of farming systems is the replenishment of the nourishment taken by the crops. This can be done by the application of manure.

The term manure encompasses all the substances added to the soil in order to increase the supply of plant Nutrients. They are classified into two main categories: organic manures and inorganic manures. Inorganic manures are otherwise known as fertilizers. They are subdivided into two groups: organic fertilizers which are usually wastes from industrial processing of part of plants or animals and inorganic fertilizers which are usually simple chemical compounds made in a factory or obtained by mining.

But the long age method of replenishing plant nutrients involves the application of organic manures on the soil, which include crop residues, farmyard manure, compost, green manure and other forms of organic materials. Their beneficial effects lie as much in the improvement of structure accruing from large additions of organic matter, as in the contribution made to soil nutrients supply.

Organic manures also encourage flourishing populations of small animals especially earthworms ,as well as microorganisms that may produce growth stumulants (indoleacetic acid, cytokinins) in the rhizosphere as advocated by Cook (1980).

Nevertheless, despite that the importance of organic manure is well known, its use has been abandoned in the developing countries like Nigeria, due to the labour involved in its handling, the absence of handling machines and also largely due to the introduction of chemical fertilizer which is easier to handle. However, despite, the introduction of chemical fertilizer, organic manure still being used in the developed countries of America, Britain and others due to its high importance and the availability of machinery for its handling and application.

Therefore, according to Bashiri (2001) a survey carried out in Kaduna revealed that no major agricultural machinery dealers sell manure spreaders which is as a result of low or no patronage due to their high cost and in the other hand, several tons of animal dung are laying waste in the major abattoirs In the cities constituting environmental hazards

So , in order to encourage the use of animal manure , to improve the sanitary condition of our abattoirs ,and to reduce the labour involved in manual application of manure , a manure spreader was designed and constructed .

But in developing countries, as is generally known, most farmers are still bound by tradition. They are understandably afraid of costly risks, and will not take them until they are convinced that the new idea is safe and will pay. Therefore it is in line with this that a performance evaluation of that locally fabricated manure spreader is being embarked upon .It is hoped that when Completed , the results that would have been obtained will convince the farmers to purchase, use such machine for increased productivity .

1.1 Justification

Since agriculture is the foundation upon which the development of the human communities have depended, governments as well as individual farmer efforts over the past century have been directed in one way or the other at mechanizing agriculture in Africa .The main thrust of these efforts have aimed at replacing traditional hand materials with draught animals, tractors , manure spreaders.....etc .

But despite the importance of manure is well known, farmers in developing countries like Nigeria are somehow neglecting it due to the drudgery involved in its application, due to the high cost of handling machines and largely to the introduction of chemical fertilizer, which is easier to handle.

But, now that the price of chemical fertilizer is too high, farmers are going back to manure and thus they are looking for easy opportunity to lessen the burdens involved in its application at moderate price. It is in line with this that a local manure spreader has been designed and constructed affordable by them.

But we know that our farmers are understandably afraid of costly risks and will not take them until they are convinced that the new idea is safe and will pay. That is why, testing of that machine in order to determine its performance characteristics becomes imperative. The results that would be derived will surely eliminate hesitations from the farmers on whether or not to purchase and use such machine

1.2 Aim and objectives

The main objective of this project is to determine the performance characteristics of that locally fabricated manure spreader.To achieve this objective, organic manure using cow dung as the major component was prepared .the characteristic to be determined i Rate of application

ii Field capacity

iii Time rate of handling manure by the machine

iv NUMBER OF LOADING PER HECTARE

v NUMBER OF TIMES THE MACHINE SHOULD BE ENLARGED TO ACHIEVE THE MINIMUM REQUIRED

1.3 Scope of the study

As stated earlier, as manures are classified in different categories, so also the manure spreaders are of different types. Therefore, this project presents an evaluation of the performance characteristics of the locally fabricated manure spreader which has its own specific principles of construction and principles of operation designed and constructed for spreading mainly solid organic manures.

CHAPTER TWO

LITERATURE REVIEW

As indicated by Phipps; et al (1959) agriculture involves the use of more machinery and power than any other enterprise. In recent years extensive use has been made of machinery to replace human labor. It was not until 1850 that the use of machinery in agriculture was of much consequence. About 1870 the adoption of farm machinery became more rapid. This was due mainly to the fact that machines were perfected so that they would work satisfactorily. In addition mechanical power became available at this time, which widened the scope of usefulness of farm machinery.

In more recent years, farm machines have been improved in quality and usefulness and their adoption by farmers has been rapid. Therefore, the modern farmer seeks ways and means of lightening his burdens and desires machines so that his own work load will be reduced.

Thus, handling manure is a good example of the rapid advance of mechanization. As outlined by Culpin (1975) until about 1945 both mechanical loaders and spreaders were regarded as something of luxury. Today, with moderately placed equipment available to increase a man's output about twenty-fold, while eliminating all the hard manual work, moving and spreading manure by hand fork should br regarded as a misuse of labour and unnecessary even on small farms. For the machine used for loading manure in the spreaders, so many scientists such as Hawkins (1949); Love Grove (1968) and Culpin (1975) have seriously discussed about them. Therefore as detailed by culpin (1986) the manure loaders now most widely used include the front-mounted tractor loaders; Hydraulic loaders; tractor mounted-slewing grabs; roughrrain fork lift loaders and mechanical gutter cleaners.

Hawkins (1949) has reported that the manure spreader was designed originally or use with houses and was therefore, a 4 wheeled machine derive from the rear wheels. For tractor use, a 2-wheel version has been produced. This classification has een also expressed by Smith (1964).

In the other hand, clupin (1986) classified the manure spreading into wheel driver and those that are power driven. In the former, all the mechanisms of the machine are driven by land wheels, whilst the latter are driven by the p.t.o shaft from he tractor. The power driven machine as an advantages over the other when field conditions are bad because it is not affected by wheel slip. because in such situation the wheel are likely to slip, leading to a lower delivery rate and risk of the feed mechanism becoming blocked. For this reason tractor spreaders may be better if power driven so that their efficiency does not depends on wheel grip. A specific investigation Carried out was indicated that the power driven is unique in that the spreading mechanism, instead of being placed at the rear, as in the normal type, is mounted at the front to reduce the length of the driving shaft. continued tests have indicated that this spreader is superior to the normal wheel-driven one under wet conditions. Both machines can be fitted with either steel on pneumatic-tyred wheels; but the latter are to be preferred when manure has to be transported over hard roads. The disadvantage of pneumatic tyres is that they may not give a positive enough drive on wet land and so will add further to the difficulties encountered with a wheel drive: this of course does not apply to a power-driven machine.

With tractor, the 2-wheeled spreader is usually better because when loaded it adds weight to the year of the tractor giving increased wheel grip. It is also more maneuverable than the four-wheel, as it can be backed much more easily. It has the disadvantage, however that when loaded, hitching up and unhitching cannot be readily carried out without some form of adjustable jack on the drawbar. This may prove a serious disadvantage if the system of working adopted depends on it being loaded in the absence of a tractor.

2.1 Manure

According to Gurdeep (1993) manure is a general term for anything added to the soil to increase its content of plant nutrients.

Normally applied to organic, usually bulky materials mostly derived from farm and animal waste products such as compost, dung, farmyard manure, slurry, sewage, e.t.c. they are slower acting then inorganic fertilizers but have the advantage of adding organic matter to the soil, increasing its capacity to retain water and improving soil structure.

2.1.1 Organic manure compost

Manure compost is a natural fertilizer made by home owner and gardeners by allowing leaves, grass, kitchen, scraps and other organic materials to rot in a compost pile.

It may contain various added chemical such as superphosphate and potash and small amount of animal manure as mentioned by Bear (new book of knowledge 1992). This decayed organic material is rich in nitrogen, phosphorus and many other food elements because it came from plants or animals that already contained all the elements necessary for growth. When this organic material is mixed into the soil it also makes the soil easier to plow and helps the soil take up and stores water.

2.1.2 The composting process

composting is the aerobic decomposition of manure or other organic materials in the thermophilic temperature range (104-149° F). The composted material is odourless, fine-textured and low-moisture and can be bagged and sold for use in gardens., or nurseries or used as fertilizer on cropland with little odour or fly breeding potentials.

composting improves the handling characteristics of any organic residue by reducing its volume and weight .composting can kill pathogens and weed seeds . There are about 5,700 on farm composters in the United states and the number is increasing . Egball (2003) .

The disadvantage of composting organic residues include loss of nitrogen and other nutrients, time for processing, cost for handling equipment, available land for composting, odour, marketing diversion of manure or residues from cropland, risk of loosing farm classification and slow release of available nutrients. During a three year Nebraska study as much as 40 percent of total beef feedlot manure nitrogen and 60 percent of total carbon was lost to the atmosphere during composting. Runoff and leaching losses of sodium(NA) and potassium (K) were also high (above 6.5 percent each) during composting periods with high rainfall. Increasing the carbon-to-nitrogen ratio by incorporating high carbon materials (leaves, plant residues, paper, sawdust, e.t.c.)can reduce nitrogen loss. In another study, a 30 percent reduction in nitrogen loss was found during composting of poultry manure in 55-gallon reactors when the C:N ratio increased from 15 to 20. Because of nitrogen, carbon and potassium losses from manure during composting, it may be more desirable to apply the manure directly as a nutrient source unless there are concerns about improving manure characteristics, Killing weed seeds and pathogens , or reducing odour problems . Youdeowei (1986) .

Temperature, water content, C:N ratio, pH level, aeration rate and the physical structure of organic materials are important factors influencing the rate and efficiency of composting. Ideal values for these factors are given in Table 1. Homogeneous manure solids can be composted alone without mixing with bulk materials. Bulking agents are needed to provide structural support when manure solids, or other residues, are too wet to maintain air spaces within the composting pile, and reduce water content and /or to change the C:N ratio. Dry and fibrous materials, such as sawdust, leaves, finely chopped straw or peat moss, are good bulking agents for composting wet manure or organic residues. Temperature is the most indicator of how composting is progressing. Elevated temperature is necessary to destroy pathogens and weed seeds in manure and other organic materials. Environmental protection agency (EPA) regulations for composting municipal waste require that the temperature be maintained at 131°F or above for that at least three days to destroy pathogens. A temperature of 145°F within the compost pile is needed to destroy weed seeds. Depending on the ambient temperature, a complete composting process may take two to six months. The water content of manure compost should be less than 50% and preferable in the range of 30 to 35%. The C:N ratio should be less than 20. R ynk, et al (1992)

Table 2.1: Recommended conditions for rapid composting

Condition	reasonable range	Preferred range
carbon to nitrogen ratio	20:1 - 40:1	25: - 30:1
water content	40 - 65%	50 - 60%
oxygen concentration	5%	5 - 15%
particle size (diameter)	1/8 - ½ inch	depends on the material
pH	5.5 - 9.0	6.5 - 8.0
Temperature	110 - 150°F	130 - 140°F

2.1.3 Composting methods

There are many methods of composting organic materials.These include active wind row (with turning) passive composting piles, passively aerated windrow (supplying air through perforated pipes embedded in the windrow), active aerated windrow (forced air), bins, rectangular agitated beds, silos, rotating drums, containers , anaerobic digestion and vermicompost (using earth worms)as detailed by Egball (2003).

2.1.4 Land application of compost

The composted material is anodourless, fine textured, low moisture material that can be used in gardens, potting and nurseries or used as fertilizer on cropland with little odor or fly breeding potential. Compost can be an excellent source of organic matter, nitrogen and other nutrients. However, nitrogen in compost is stabilized and not as easily available to the crops as nitrogen from raw material. Availability of phosphorus, potassium, and micro nutrients from compost should be similar or higher than manure or other organic residues used for composting . since compost is fine textured and has less water than raw material it can be applied more uniformly and with better control.

The composted material also can be stored and applied when convenient. Weed seeds or pathogens that can create problems with application of manure or other organic residues should not be a concern when properly made compost is used.

2.2 Method of application of manure to the soil

According to Bashiri (2001) the two major methods of applying manure to the soil are the manual method and the machine method.

2.2.1 Manual method

Manual application is the earliest form of applying fertilizer to the soil. In this method the fertilizer is applied using the hand either by scattering or by placement close to the plant. Although this method is very effective, it is very laborious and can only be used where the land area is small. This method is still in practice by the small holder farmer with small plots of land.

2.2.2 Machine application

Advancement in technology has brought about the development of different machine for the application of both chemical and organic manure. The development of this machine brought about the cultivation of larger land areas as the drudgery involved In manual effort is reduced leading to increased productivity.

2.3 Manure spreaders

Despite the importance of manure as the main source of plant nutrient was known since ancient times, it was majorly applied manually. The scientific and technical discoveries and inventions made since the last century have made a significant contribution towards increasing agricultural productivity. In the line of those discoveries was the introduction of the equipment called manure spreader.

According to Stone and Gulvin (1978), a wagon type spreader was invented in 1865 by Joseph kemp whose patent for the first mechanical spreader were purchased by John Deere and company. In 1977, the endless apron or conveyor was used as the first commercial spreader, since then, manure spreaders have been widely used for carrying manure to the field and shredding it uniformly over the land. The spreader is labour saving and efficient and does a better job of distribution than can be done by hand.

2.3.1 Types of manure spreaders

Shippen et al (1980) have noted that a variety of machines are available for spreading manure. As stated earlier, the manure spreaders used are of two main types, those that are wheel driven and those that are power driven. What is required of a manure spreader is that it should hold a reasonable quantity of manure for transporting and that it should spread this manure evenly across the field at different rates of application as desired. These requirements are generally met with the type of spreaders available and apart from the way in which they are driven, probably the main difference between most makes is in the amount of manure that can be carried. The quality of the amount of manure carried is usually not less than 1.5 tonnes in the smallest spreaders, whilst the largest carried about 4 tonnes. Generally, the rates of application of the manure applied to the field can be varied from 12 and 60 tonnes per hectare (5-25 tons per acre) in 5-tonnes increases.

2.3.1.1 Component of manure spreader

According to Kaul and Egbo (1985). thei manure spreader comprises:

a. **the storage unit**

this consist of a box somewhat like a tractor trailer. The rear end of the box is open to allow for the fixing of a metering/distribution mechanism.

b. **the metering /distribution mechanism**

it consists of the following:

i. **the conveyor**

An endless double chain – and –slat conveyor apron that forms the base of the manure box .When the chain moves it carries the manure to the rear of the machine from where it falls to ground after being broken into smaller pieces by the beater .

ii **the beater**

This consists of steel bars (to which teeth are fixed) arranged in a cylindrical pattern. There are usually two sets of beaters. The lower set and the upper set. The lower beater Shreds the manure into small fragments. The upper beater assist in this operation and further pulverizes the manure pieces. The lower beater revolves in the opposite direction to the wheels of the tractor or spreader and usually 6 to 7 times faster.

c. **The drive system.**

This is to run the beaters and conveyor apron. These may be run either from the wheels of the manual spreader or from the tractor power-Take - off. The latter system is preferred in bad traction conditions or where very lumpy manure has to be handled.

A ratchet-and-pawl arrangement is generally used to drive the conveyor aprons. The speed of the conveyor apron determines the volumes of the manure distributed.

d. **the spreading device**

this is usually in the form of a spiral auger, which is attached above the beaters to give a wider spread to the manure being discharge and is usually driven by a chain from the beater shaft.

2.3.1.2 Trailer spreaders

As vigorously emphasized by Bell (1966) a long established type consists of a low wagon with a traveling bed which carries the load of manure slowly and uniformly towards revolving beaters at the rear of the machine. The beaters tear the manure into small fragment and an additional cylinder scatters it over a strip wider than the machine. A suitable factor for estimation of load carried is $30ft^3$ ($0.85\ m^3$) of truck capacity per ton .

In some machines the final spreading is carried out by a flail-type beater which is well balanced, and designed to rotate at a high speed. This type of mechanism can produce a thorough pulverization but requires more power than one with a low speed main beater shaft e.g 600-700 r.p.m where chains are used they need to be designed to withstand heavy loads in conditions which make good maintenance almost impossible. Drive to the conveyor is usually by an easily adjusted ratchet mechanism, the rate of spread being varied by adjusting the throw of a rocker arm. Spreading rates can usually be varied from about 3 to 20 tons per acre (7,500-50,000 kg/ha).

The flail type side spreader with a long semi cylindrical tank, has a p.t.o driven shaft running along its axis. A number of chains attached to the shaft rotate at a fairly high speed and gradually extend as they work into the load from both ends. The main advantage of such a machine is its simplicity and its ability to handle very wet materials.

Achievement of good results with side-distributing flail spreaders require skill and judgement on the part of operators. Filling should begin by putting forkfuls beyond the rotor. If the loader are operated by separate tractors, the p.t.o. drive of the spreader tractor should be slowly engaged when the machine is half full, to settle the bottom of the load and to wind the chains round the rotor. The ends of the rotor should be only lightly loaded.

Spreading rate is governed by tractor throttle setting and forward speed. If uniform speeds are used throughout, spreading will not be uniform because when the spreader is two-thirds empty, many flails are operating effectively and spreading rate tends to be higher. At this point, therefore, it is necessary either to reduce throttle setting or change to a higher gear. the operator needs to use his judgement continuously to decide what forward speed and throttle setting are required. Bout width is usually about 3m (10 ft).

2.3.1.3 Heap spreaders

A heap spreader is usually a mounted or semi-mounted power driven machine employing the same basic principles as the spreading mechanism of a trailer spreader. Although few are used today, they are relatively cheap and successfully handle the manure-spreading problem of small farms.

The manure must first be moved from the yard, buildings or heap, to the field, and deposited in small heaps at regular intervals in rows 12 to 15 ft apart. This may be done with a tipping trailer. The spreading outfit is then driven down the rows straddling the heaps; as with trailer-types machines, a shredding beater disintegrates the material and spiral spreader distributes it. Reducing the ground speed by means of the tractor gear box, gives greater pulverization of the manure, and a second 'pass' is sometimes made to improve further the distribution. Love Grove (1968).

2.3.1.4 Rotary spreader

One successful departure from the conventional type of trailer spreader is rotary spreader. It has a watertight cylindrical container, the contents of which are discharged by revolving chain flails carried on a common spindle and powered by the tractor p.t.o.

This revolutionary design has a number of advantages: it can handle both solid and liquid manure; it achieves a high degree of pulverization of the solid manure; it gives a consistent spread; its simplicity of design makes for reliability and minimum of maintenance requirements. Love Grove (1968).

2.3.1.5 Liquid manure spreaders

Liquid manure drained at the cattleyard and in other areas is collected in a sump from where it can be pumped to liquid manure tankers. The tankers are usually large (800 to 1200 liters capacity or more) and generally of the trailed type. The tank is galvanized or coated internally with an anti-corrosive substance.

The liquid is then discharged from the tank to a splash plate or rotating disc for even distribution in the field. Kaul and Egbo (1985)

2.3.1.6 Dual-purpose spreaders

Developments include machines designed to handle both solid manure and sluries. A successful type employs a hopper with a u-shaped bottom, and a full length flighted rotary horizontal conveyor running near the bottom to carry manure forward to a variable width opening on one side near the front. When the opening is fully closed by a hydraulically operated sliding gate. The tank can be reasonably water tight. The manure is pushed through the controllable gate to a high-speed impeller with axis parallel to the auger-type main conveyor and the direction of travel. A spring loaded flap can protect the impeller from damage by large foreign objects in the manure: Additional over load protection is provided in the main drive.

A well distributed wide swath limits soil damage by wheel tracks. The forward moving load helps to maintaine tractor wheel adhesion. Culpin (1986)

CHAPTER THREE

MATERIALS AND METHODS

Measures of agricultural machine performance are the rate and quality with which the operations are accomplished. Rate is an important measure because few industries require such timely operations as agriculture with its sensitivity to season and to bad weather. Completeness is that portion of quality, which describes a machine's ability to operate without wasted motion or wasted product. Therefore, it is necessary to consider the quality as well as the quantity when computing machine performance. Hunt (1973)

Thus, for adequate evaluation of the performance characteristic of a given machine, proper information on the machine principles as well as on the material to be handled are important. Therefore the starting point of the research was the presentation of the:

a. Preparation of organic manure compost

b. Principles of construction and operation of the locally fabricated manure spreader.

3.1 Preparation of organic manure compost

Depending on availability, compost has been made in quite a variety of ways using a varied combination of materials. the major raw material for making compost are animal dung, straw, leaves, ash, urine and other decomposable organic materials. The end product of properly decomposed compost is a fine powder called humus (Yeshwant, et al; 1981).

3.1.1 Composting site

The site selected for carrying such manure composting activity is a 10 m x 10 m area situated at the end west of the football ground in the Federal University of Technology , Minna .

3.1.2 Clearing of the selected area

Hoe, rake and shovel were first of all used to clear the vegetation developed on that selected site as a result of the coincidence of that experimental period with the raining season. Such materials added with digger helped digging the experimental pits.

3.1.3 Preparation of the compost pits

By using such materials listed above, three experimental pits were dug side by side. All the three pits had the same dimensions. Each pit was 1.2m wide, 0.6m deep and 1.5m lengths. A distance of 1.5m was considered between two consecutive pits.

3.1.4 Composting materials

The following materials were collected for the preparation of the compost: cow dung, ash, grasses, leaves and, including then water and air which are necessary for the compostingprocess.

3.1.5 Building of pile in the first pit

The pile was built inside the pit in such away that the materials were arranged in the following way:

a. Chopped grasses were laid at the bottom of the pit as the first layer.

b. The second layer was formed with chopped leaves.

c. The third layer encompassed the cow dung. This was to accelerate the activities of decomposing microorganisms such as fungi and bacteria.

d. The fourth layer was constituted with ash.

e. This process of laying the materials was repeated until the pit was filled.

f. Water was then added at the desired moisture content.

g. Some poles were pushed into the pile to allow air to get into the layer beneath.

3.1.6 Building of heap

Alternatively, an area of 1.2m x 1.5m was demarcated in one side of the composting site. This was used to build a heap so that the rate of decomposition of the compost could be compared with that of pit method. One stake was knocked into each of the four corners of the selected land area with two other stakes positioned half way between the 1.5m length dividing then the land into two plots for supporting the heap. The building of the pile as well as all processes attached for making the compost were the same as in the pit method developed above.

3.1.7 Turning and watering of the compost

At every two weeks, the compost was turned from pit A to B and B to C for the pit method and from Area 1 to 2 and 2 to 3 for the heap method. At any time the compost was turned from one pit to another or from one area to the other, it was watered at desired moisture. After the compost reached the two weeks in the last pit as well as in the last area, it was ready for use. See fig A, B, C.

3.1.8 Second loading of compost in the released pit one

In order to compare results from different ways of piling compost in the pit ,another nev compost was loaded in the pit one immediately when the first loaded compost left that pit one t(the second pit .the pile in this case was arranged in the following way :

a. Complete layer of chopped grasses constituted the first layer.
b. This was followed by a complete layer of chopped leaves forming the second layer.
c. The third layer encompassed the animal dung.
d. And then at last, the remaining space of the pit was filled with ash constituting the fourth and last layer.
e. Pushing of poles, watering and turning process were the same like that of the first loading of the compost.

3.1.9 Temperature record during composting

As reported by Yeshwant, et al (1981) that the activity of various microorganisms is easily followed from temperature record, temperature plays a very important role in the decomposition of the material by bacteria and fungi. Too high or too low temperature is harmful to them. 65°C was found to be the optimum requirement for microorganism to breakdown cellulose. The aerobic thermophylic bacteria thrives best between 43°C and 63°C and fungi between 40 and 50°C.

Thus because of such importance of temperature, a thermometer was inserted into the pits heap every week and thus the records were presented in the

Table 3.1: Records of temperature for the 1st loaded pit compost

Weeks	Temperature
1	45
2	53
3	55
4	61
5	50
6	58

Table 3.2: Records of temperature for the 2nd loaded pit compost

Weeks	Temperatures
1	40
2	49
3	51
4	58
5	50
6	52

ble 3.3: Records of temperature for the heap compost

Weeks	Temperatures
1	35
2	41
3	38
4	45
5	37
6	42

3.1.10 Moisture content of the experiment compost

First of all, according to Sidney (1963), moisture content of a material is defined as the ratio of the weight of water to the weight of the solid in the same volume expressed in percentage basis.

Therefore ,the first loading pit compost was used to carry out the testing operations of the ocal spreader . After the compost was reached 2 weeks into the second pit , a sample of 278.03 g vas taken and oven dried . the new weight was recorded as 191.24 and the moisture content was computed as follows :

Moisture content for that first loaded compost is noted as MC 1, and we know

$$\text{moisture content} = \frac{\text{Weight of water}}{\text{Weight of dry sample}} \times 100\%$$

So $$MC_1 = \frac{ww}{ws} \times 100\%$$

$$MC_1 = \frac{(278.03 - 191.24) \times 100\%}{191.24}$$

$MC_1 = \frac{86.79}{191.24} \times 100\%$

$MC_1 = 45.38\%$

The same sample of 278.03g was taken from the second loaded pit after reaching the 2 weeks in the second pit and then was oven dried. The new weight after that was 197.85g.

Therefore $MC_2 = \frac{(278.03 - 197.86)}{197.86} \times 100\%$

$MC_2 = \frac{80.17}{197.86} \times 100\%$

$MC_2 = 40.52\%$

And then lastly, the same sample of 278.03g was collected from the heap compost after the end of the 2 weeks in the second area. It had been oven dried and the new weight was 201.54g. Its moisture content was determined as follows:

$MC_3 = \frac{(278.03 - 201.54)}{201.54} \times 100\%$

$MC_3 = \frac{76.49}{201.54} \times 100\%$

$MC_3 = 37.95\%$

3.1.11 Bulk density of The compost used during the test

(Compost from the first loaded pit)

According to Sidney (1963), the bulk density of a material is defined as the total weight including the weight of water per unit volume. It is expressed as follows:

$$\rho_H = \frac{wt}{v}$$

Where ρ_H = Bulk density (Kg/m^3)

wt = Total weight of solid and water (kg)

v = Volume of core sample (m^3)

A core sample of 20cm diameter and 10cm height was sunk into the compost. The manure surrounding the core sampler was removed. The sampler was weigh ed and the following was obtained:

The weight of empty core sampler is w_1 = 0.0305 kg

The weight of the core sampler when loaded is w_2 = 2.797kg

Total weight of compost (solid + water) in the core sampler was:

$w_2 - w_1$ = 2.797kg – 0.305kg = 2.493kg

Therefore the Bulk density of such compost was:

$$\rho_H = \frac{2.493kg}{(\Pi r^2 h)cm^3} = \frac{2.493}{100\Pi x10} = \frac{(2.493) \times 10^6}{1000\Pi} = 793.64kg/m^3$$

ρ_H = 993.64 kg/m^3

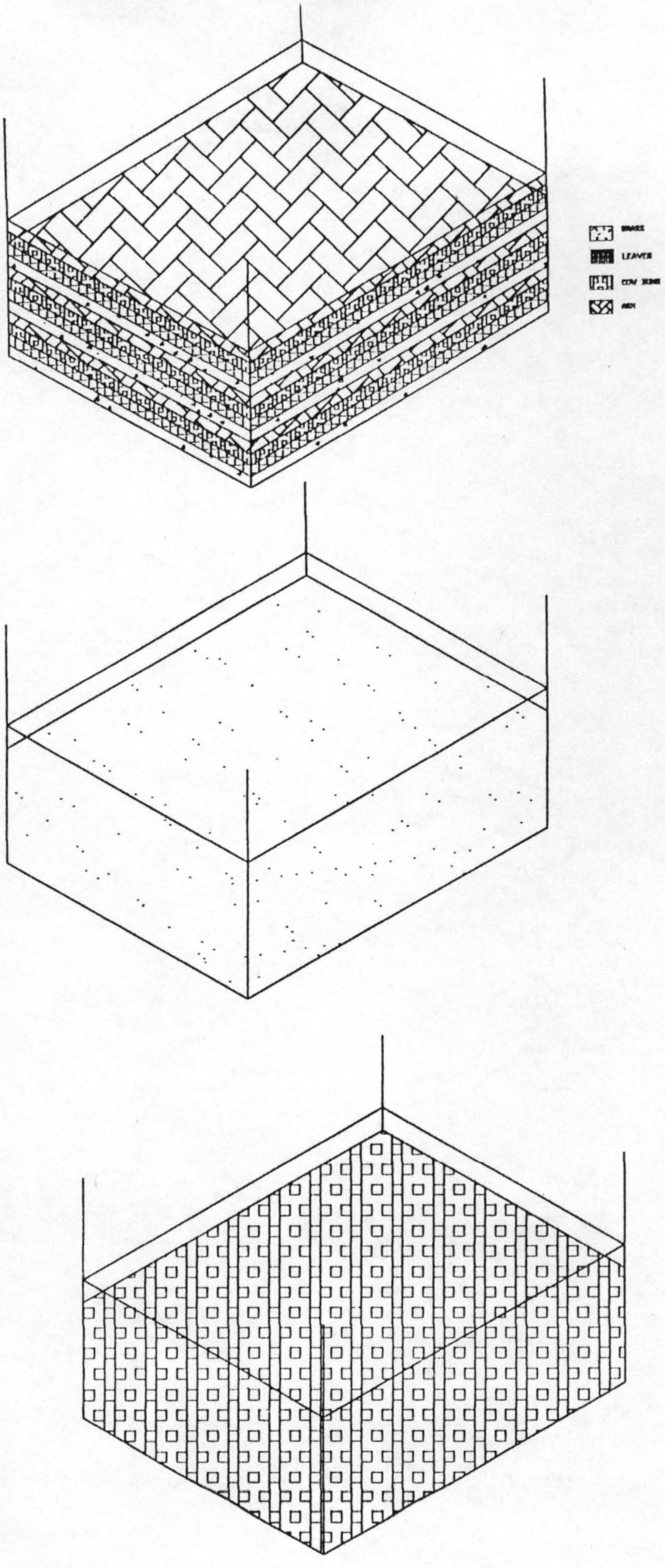
Therefore, the amount of such compost that the spreader's Hopper can take was: since the volume of the Hopper is $0.335m^3$

That amount should be: $\frac{0.335m^3 \times 793.64 \text{ kg}}{1m^3}$ = 265.86kg

A

B

PIT C



: STAGES OF DECOMPOSITION OF THE FIRST LOADED PIT COMPOST

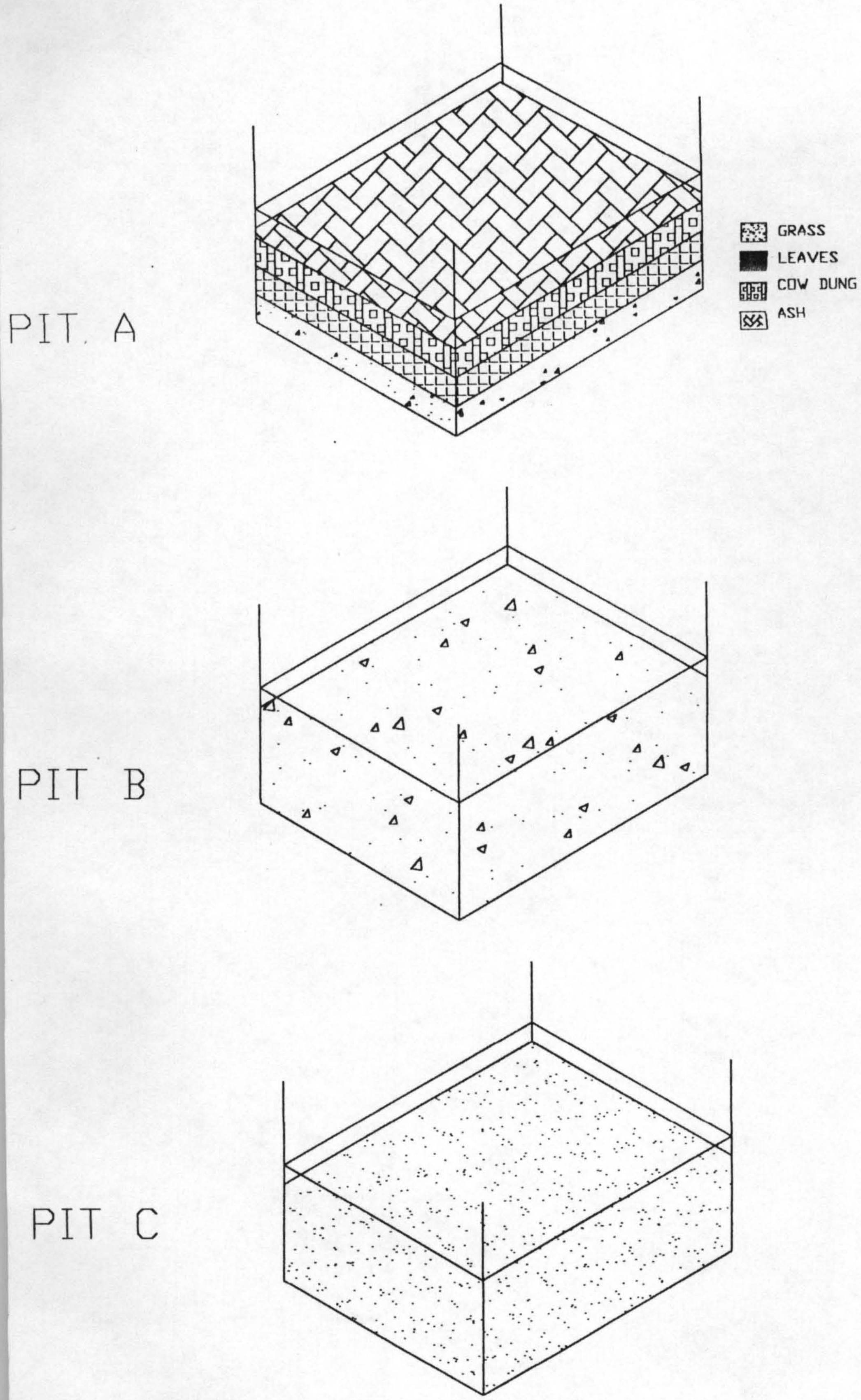


FIG 3.2: STAGES OF DECOMPOSITION OF THE SECOND LOADED PIT COMPOST

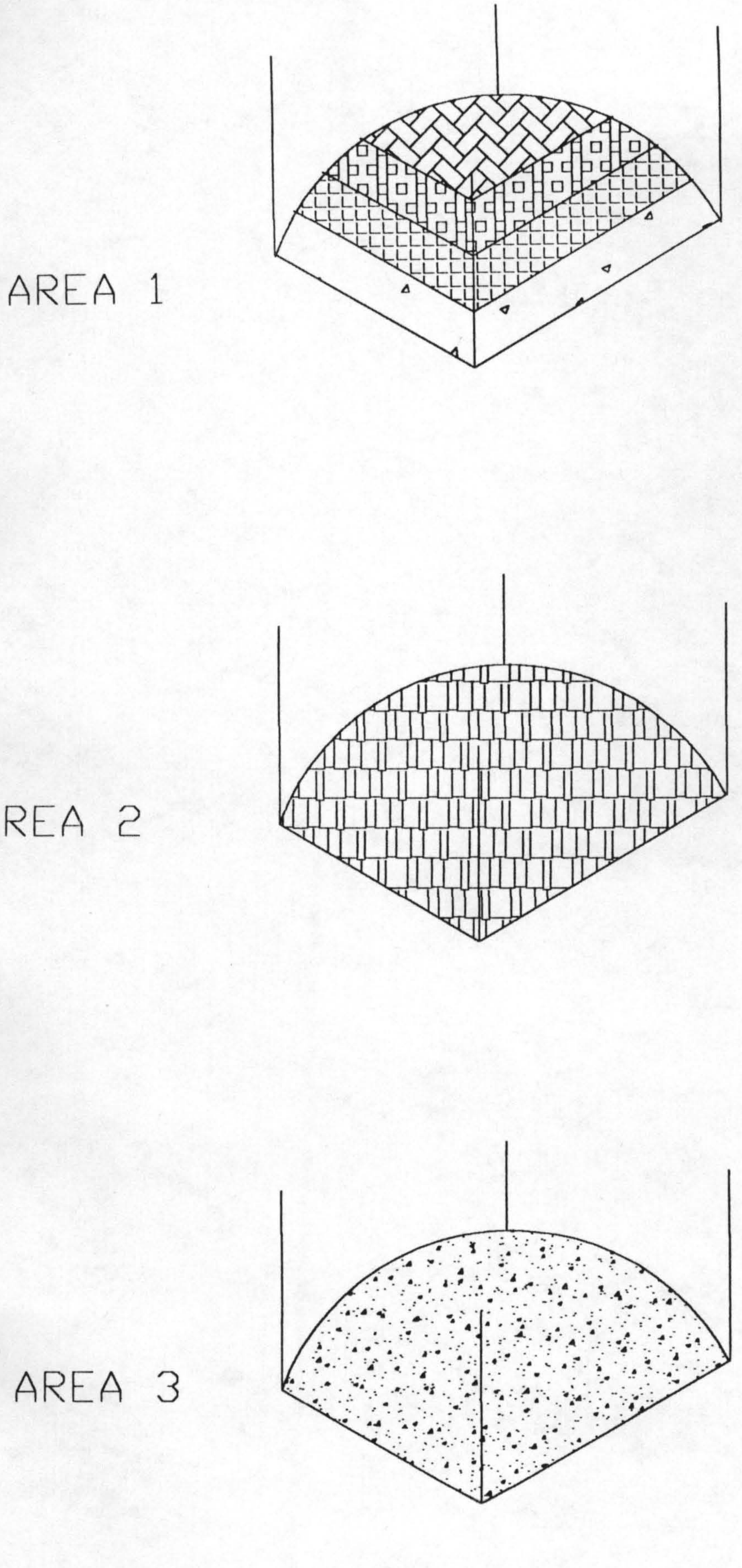


FIG 3.3: STAGES OF DECOMPOSITION OF THE HEAP COMPOST

3.2 Principles of construction of the spreader

3.2.1 The Hopper

The hopper was constructed using a 2mm thick metal sheet. It was made into a rectangular top and trapezoidal shapes. The total mass of the hopper is 26.848kg with $0.335m^3$ in volume. It can contain up to 250kg of manure depending on the manure's density. It is supported by Four 350x45x5mm mild steel bars.

3.2.2 The spreader frame

This is the carrier of all other components of the machine. Since rigidity and strength are the most important criteria to be considered, it is constructed with a square hollow steel section of 40 x 40mm welded into a rectangular shape of 1080mm x 800mm x 5mm.

3.2.3 The driving unit

It encompasses a telescopic shaft of 35mm diameter, a gearbox with bevel gears. The driven gear wheel has 35 teeth while the driven pinion gear has teeth. The gearbox has an output shaft of 40mm diameter consisting of pinion gear at one end and a pulley at the other end supported by two bearings. Two belts with 16.7mm width and 10.3mm depth each were selected one to drive the flail spreading mechanism and the other to drive the agitator. Three pulleys were selected for the machine: one driver pulley of 110mm pitch diameter, another one driven pulley attached to the spreading mechanism rotor of 160mm pitch diameter and the last also driven pulley of 260mm pitch diameter attached to the manure agitation in the hopper.

3.2.4 The spreading mechanism

It consists with a shaft that has flails attached through out its length. The shaft is supported on two bearings with a pulley attached to one of the ends. The diameter of the shaft is 40mm. The fails are made of small pieces of metal bars welded to the rotor, a hook passing through a bar and two pieces of metal bars attached to the hook.

3.2.5 The manure agitator

A screw conveyor type agitator has been adapted for this machine. It is made up of rotor with left hand sand right hand flights welded along its periphery. It comprises with an inside diameter of 40mm on which the flighting is welded, an outside diameter of 200mm which is referred as the screw diameter. It has a strip width of 80mm, which is the length of the flights from the inner portion welded to the shaft to the outside tip of the flights. The pitch of the manure spreader auger is 32mm. The screw length, which is the total length of the spreading auger, is1000mm. The thickness of the material used for the construction of the flight or screw is referred as strip thickness and is 3mm.

3.3 Principles of operation of the manure spreader

The manure spreading mechanism is driven by the power taken from the PTO shaft through a telescopic shaft into a gearbox with bevel gears, which the drive is taken out through an output shaft at an angle of 90^{o}. The output shaft has a pulley attached to the other end to which belts transmit the drive to the spreading rotor. The manure agitator is located inside the hopper while the spreading shaft is at the bottom of the spreader. When the PTO shaft of the tractor is engaged, both the manure agitator and the spreading shaft rotate at the same time.

When the manure is loaded in the hopper, a gate at the bottom of that hopper controls it in order to avoid it reaching directly the spreading zone even before the machine is engaged. The incorporation of the agitator into the hopper allows ease of flowing of the material to the spreading zone. So as it is rotated, the spiral flight propelled the compost out of the hopper, therefore reaching the spreading flails, which distribute it on the field.

3.4 Pto and draft power requirements of the spreader

According to Bashiri (2001), the total power required by that locally fabricated manure spreader at the PTO to shaft is 4.978kw.

The pull required by tractor to pull such machine is equal to 5.069kw.

Therefore the speed of the tractor while using such machine should be 5 km/hr.

Components of the machine

Part n^0	Part name		
1	Hopper	9	Idler pulley
2	Hopper support bar	10	Flail spreader sh
3	Frame	11	Flail spreader sh
4	Gear box	12	Spreader wheels
5	Telescopic shaft	13	Agitator sheave
6	Tool bar	14	Agitator shaft
7	Gear box output shaft		
8	Driver sheave		

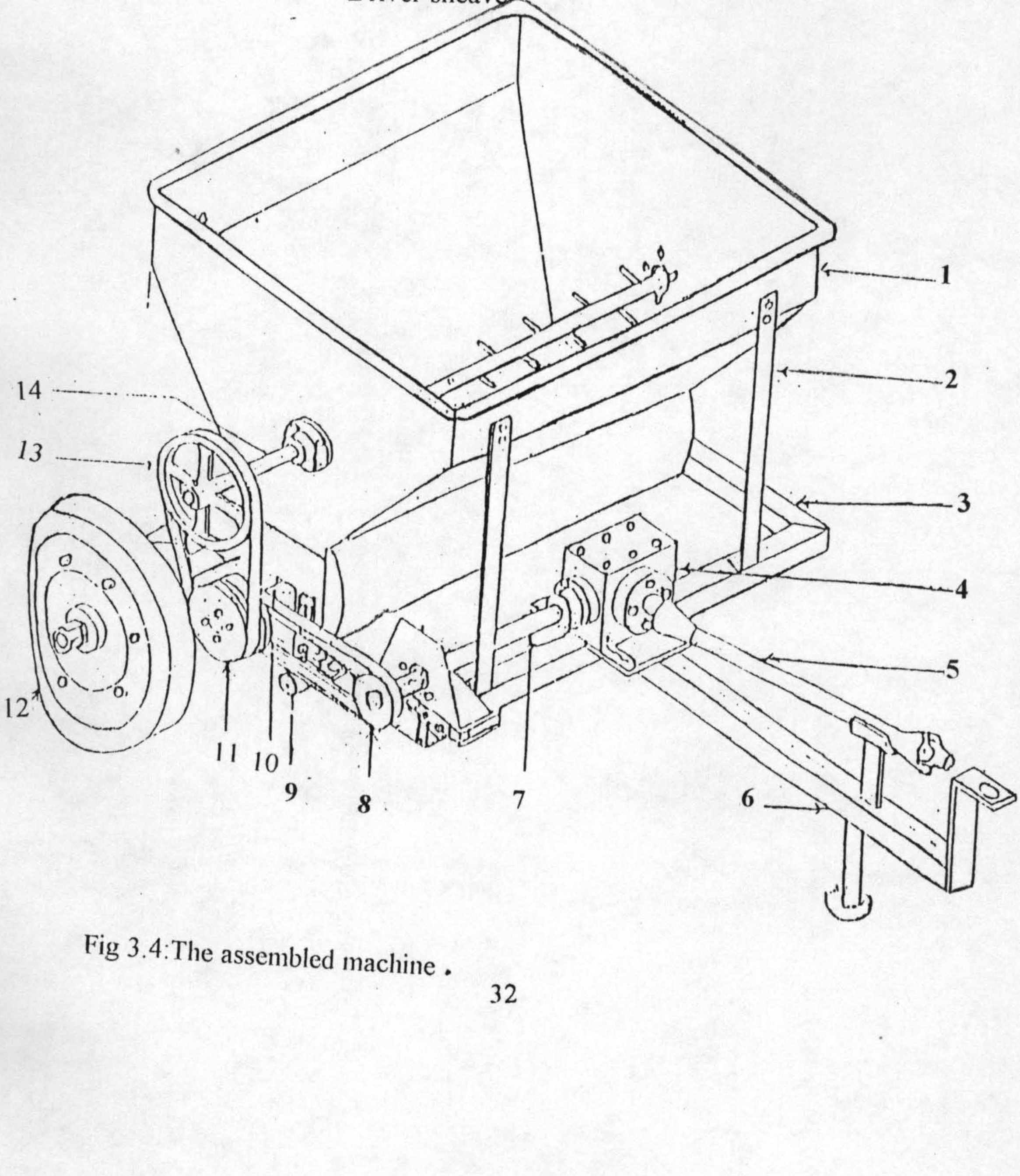


Fig 3.4:The assembled machine .

3.5 Testing procedure of that machine

a. Material

The material used for the test was the compost made with bulk density of 793.64kg/m^3.

b. The field

The field selected for carrying such test was the Bitrus Sawa Zone in the Federal University of Technology, Minna

c. The test

It consists of determining the rate of application,the field capacity of such manure spreader, and time rate of handling manure by it.

3.5.1 Determination of the rate of application

The preferred method of determining the application rate is by measuring the amount discharged the spreader during operation over a known area.

i. Procedure

To carry the test , a number of compost heaps with equal weight is to be taken and spread them one by one with that machine .then compute distance ,width ,and time for each heap spreaded .thus :

a. 7 heaps of 50kg each were collected from the compost made to be used for the test.
b. The first heap was put into the hopper and the tractor was engaged under 5km/hr as forward speed as recommended from the design of that machine and a PTO speed of 540rpm until that compost was completely spread meaning that there is none in the hopper
c. The same procedure used for the first heap was used for the remaining 6 heaps and the following results were computed as indicated in the

Subsequent section of this research. By using the following formula :

$$R = \frac{QK}{LW} \quad ------(1)$$

Where R = Application rate (tones/ha)

Q = weight applied (tonnes)

W = swath width (metres)

K = constant 10,000

L = distance traveled by the spreader to spread the quantity of manure in the hopper (metres).

3.5.2 Determination of the Field capacity of the machine

The field capacity of a machine is the rate at which it can cover a field while performing its intended function or useful work.

i. PROCEDURE

a. The average value of the time taken for the running of the spreader should be computed.

b. The mean distance traveled by the machine should be obtained.

c. With a and b, the speed of the spreader can be determined as:

$$\text{Speed} = \frac{\text{average distance}}{\text{average time}}$$

d. The mean width should also be available and thus the field capacity can be calculated by using:

$$C = S \times W \quad -------------(2)$$ Hunt (1973)

3.5.3 The time rate of handling manure

This value determines the weight of that compost that the spreader can spread per unit time. It can be expressed in t/hr. getting the application rate of such machine in t/ha and the field capacity in ha/hr, the time rate of handing manure of that machine can be computed by simple analogy.

CHAPTER FOUR

RESULTS AND DISCUSSION

In the course of this activity, the following areas were investigated and the results are as follow.

4.1 Preparation of organic manure compost

After composting cow dung, grasses, leaves, ash, including air and water of some quantity at about six weeks with 2 different methods of composting (pit and heap methods) as well as 2 different forms of pile arrangement within a particular method (pit method), the following have been noticed:

4.1.1 Temperature during the process of composting

As indicated earlier, temperatures were recorded weekly

The mean temperatures obtained were:

a. The mean temperature recorded in the process of composting the first loaded materials in the pits was:

$$MT_1 = \frac{45 + 53 + 55 + 61 + 50 + 58}{6} = 53.66^0C$$

b. The mean temperature obtained in the process of decomposition of the second loaded materials in the pits was:

$$MT_2 = \frac{40 + 49 + 51 + 58 + 50 + 52}{6} = 50^0C$$

c. The mean temperature recorded from the heap was:

$$MT_3 = \frac{35 + 45 + 38 + 41 + 42 + 37}{6} = 39.66^0C$$

From this, it was noticed that the MT_1 felt within the preferred range for rapid composting proposed in table 1.

And MT_2 felt within the reasonable range given in that table 1.

But the MT_3 recorded was too low for the establishment of fungi and bacteria which are responsible for the decomposition process.

Therefore, MT_1 was much more desirable followed by MT_2.

4.1.2 Moisture contents computed after four weeks of decomposition of the manure

The following results were obtained:

a. 45.38% was obtained from the first loaded materials and is noticed as MC_1

b. For the second loaded material the moisture content was MC_2 = 40.52%

c. MC_3 = 37.95% represented the moisture content obtained from the heap compost.

The result showed that the best preferred moisture content was obtained from the first loaded pit compost followed by that of the second loaded pit compost which was acceptable. But that obtained from the heap was not encouraging due to lack of enough temperature within it.

Therefore, from all the results obtained from the three different composts in terms of temperatures and moisture contents derived during the process of their decomposition, it has been observed that pit method is much more better for rapid composting than the heap method. And also, mixed piling (arrangement) of different materials for making compost is much more better than separate piling within the pit method.

In fact, even by naked eye, it was clear that the first loaded compost obtained was more decomposed than the second loaded one and that second pit compost was much more better than the heap one.

Therefore, the first loaded pit compost was used for carrying the machine test.

4.2 Test results

As stated above, the first loaded pit compost obtained with bulk density determined as $\rho_h = 793.64 kg/m^3$ was used for the test. The amount of such material that the machine's hopper can take is determined as 265.86kg. Therefore the following results are obtained from the test as:

4.2.1 Distance, widths and time values recorded

4.2.1.1 Distance recorded

The different distance covered by the spreader after complete spreading of each heap can be tabulated as follow:

Table 4.1: Distance recorded

Heaps (0.05 tones each)	Distance covered (metres)
1	$d_1 = 83.38$
2	$d_2 = 99.59$
3	$d_3 = 104.0$
4	$d_4 = 101.33$
5	$d_5 = 81.06$
6	$d_6 = 118.12$
7	d_7 148.23

Therefore, the mean distance covered was:

$$d = \frac{d_1 + d_2 + d_3 + d_4 + d_5 + d_6 + d_7}{7}$$

$$d^{\cdot} = \frac{83.38 + 99.55 + 104.80 + 101.33 + 81.06 + 118.12 + 140.23}{7}$$

$$d = \frac{736.51}{7} = 105.21m$$

$$d = 105.21m$$

4.2.1.2 Spreading widths obtain

The different spreading widths measured from the field after the spreader spread each of the 7 heaps can be computed as follow:

Table 4.2: Widths obtained

Heaps (0.05 stones each)	**Spreading widths (metres)**
1.	W1 = 1.17
2.	W2 = 0.98
3.	W3 = 0.93
4.	W4 = 0.96
5.	W5 = 1.2
6.	W6 = .82
7.	W7 = o.66

Thus the mean width obtained was:

$$W = \frac{w_1 + w_2 + w_3 + w_4 + w_5 + w_6 + w_7}{7}$$

$$W = \frac{1.17 + 0.98 + 0.93 + 0.96 + 1.2 + 0.82 + 0.66}{7}$$

$$W = \frac{6.72}{7} = 0.96$$

$$W = 0.96m$$

4.2.1.3 Value of time recorded

The time values recorded are as follow:

Table 4.3: Time recorded after spreading each heap

Heaps(0.05 tons each)	Time taken to be spread (Sec)
1	$t_1 = 62.88$
2	$t_2 = 74.32$
3	$t_3 = 80.03$
4	$t_4 = 74.32$
5	$t_5 = 57.16$
6	$t_6 = 85.75$
7	$t_7 = 108.62$

Therefore, the mean of the time records was:

$$t = \frac{t_1 + t_2 + t_3 + t_4 + t_5 + t_6 + t_7}{7}$$

$$t = \frac{62.88 + 74.32 + 80.03 + 74.32 + 57.16 + 85.75 + 108.62}{7}$$

$$t = \frac{530.25}{7}$$

∴ $t = 75.75$ Sec

4.2.2 Rate of application

The rate of application can be calculated from the formula ;

As stated earlier, R=QK/LW

From the test we have,

Q = 50kg = 0.05 tons

L = d = mean distance covered = 105.21m

W = mean width of spreading obtained = 0.96m

So, $R = \frac{10000 \times 0.05}{105.21 \times 0.96}$

$R = \frac{500}{101.0} = 4.95$ tons/ha

R = 4.95 tons/ha

4.2.3 Determination of the field capacity of the machine

The field capacity can be calculated as:

$C = (S \times W) \times 10^{-4}$ (Hunt)

Where C = field capacity in ha/hr

S = speed of the machine m/hr

W = width of spreading in m

$S = \frac{\text{average distance}}{\text{average time}} = \frac{105.21m}{75.75sec}$

C = 1.38m/sec

C = 1.38m/sec x 0.96m

C $1.324 m^2/s$

C $\frac{(1.3248 \times 10^{-4} \times 3600) ha}{1 hr}$

C $0.476 ha/hr$

4.2.4 Time rate of handling manure of the spreader

According to Hunt, this implies the act of experiencing the capacity of a machine in terms of weight of material handled per unit time.

The time rate of handling manure by the spreader was:

It is known that the field capacity of the machine was 0.046ha/hr, so for that machine to cover 1 ha it will take the following time:

$\frac{1 ha \times 1 hr}{0.476 ha}$ $2.1 hrs$

The application rate of the spreader was 4.95t/ha. And the machine will take 2.1 hrs to cover 1 ha, therefore the time rate of handling manure by the spreader was:

$T_c = \frac{1 \times 4.95t}{2.1 hrs}$ $2.35t/hr$

$T_c = 2.35t/hr = 39kg/min$

This implies that the machine should be enlarged.

4.2.5 Numbers of Loading that has to be done before covering 1 ha by the local spreader

As noted above, the machine's hopper could carry only 265.6kg of such compost.

And the machine's application rate was determined as 4.95t/ha which is equivalent to 4950kg/ha.

Therefore, the number of loading before covering 1 ha by the spreader can be calculated as:

$$\frac{4950}{265.86} \quad 18.61 \quad \approx \quad 19$$

Thus, the machine would be loaded for about 19 times before covering area of 1 ha. This also implies that the machine should be enlarged.

4.2.6 Number of times the machine should be enlarged to cover the minimum required

According to Shippen et al (1980), the quantity of manure carried is usually not less than 1.5 tones in the smallest spreaders .

From that , we know that the capacity of the local spreader is 265.86 kg .

To cover the minimum requirement, the local spreader should be enlarged as:

$1500/265.86 = 5.64 \cong 6.$

thus ,it should be enlarged for about six times to cover the minimum requirement .

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The aim of determining the performance characteristics of the locally fabricated manure spreader has been achieved in the course of this research. The results obtained for field capacity was 0.476ha/hr. and that of rate of application was 4950kg/ha. The time rate of handling manure by that machine was 2.35tons/hr.

However, the results obtained were very encouraging as that machine being the first attempt of constructing a manure spreader in this locality. Thus, further work is required to improve upon the results obtained above, after which a bigger capacity spreader can be produced to handle larger hecterage of land.

5.2 RECOMMENDATIONS

In the process of testing such machine, some observations were made and the following recommendations were suggested.

a. Improvement of the Hopper's capacity is highly necessitated for reducing frequent loading of the spreader before covering a specific area.

b. As a result of difficulty of the manure to flow from the Hopper to the spreading zone, a left and right hand screw hanger should replace the present agitator which is a shaft with spikes. If not only complete dry manure can be easily spread by that machine.

c. As far as increasing the machine's capacity of holding manure is very crucial and imperative, replacing the belts with chains is also essential.

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Appendix A

ANIMAL PRODUCTION IN NIGERIA

TYPE OF ANIMAL	POPULATION (MILLIONS)
CATTLE	13,761,000
SHEEP	21,230,000
GOAT	33,867,000
HORSE	200,000
CAMEL	87,000
PIGS	3,367,000
CHICKEN	71,164,000
ALL OTHER POULTRY	29,937,000

APPENDIX B

ANNUAL DUNG PRODUCTION .

	ANIMAL	POPULATION (M)	DUNG PRODUCED TONS/ANNUM	TOTAL DUNG TONS/ ANNUM
1	CATTLE	13,761,000	1.10	151371000
2	SHEEP	21,230,000	0.15	3184500
3	GOAT	33,867,000	0.15	5080050
4	HORSE	200,000	0.55	110000
5	CAMEL	87,000	0.80	67600
6	PIGS	3,367,000	0.25	841780
7	CHICKEN	71,164,000	0.09	810,4760

SOURCE: NATIONAL LIVESTOCK PRODUCTION DIVISION KADUNA 1985

Plate I: digging of the compost pits.

Plate II : Turning of the heap compost .

Plate III : The composting site.