COMPOSTING: Fundamentals and design considerations

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MANUAL

PREFACE

This manual provides an overview of compost development and its poduction for soil ammendments to increase productivity. Traditionally, farmers are using manure as organic fertilizer. However, the application of manure has many side effects as it has volatile chemicals and bulk mass. The production and use of compost on the other hand is not clearly defined to farmers as a best soil ammendment practice to improve soil fertility and crop production. This manual, will provide guidelines by highlighting the major activities in the proccess of composting.

ACKNOWLEDGMENTS

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1. Introduction

One of the first steps in good farming practices is to develop an organic farming system using agric biomass and other organic wastes in harmony with nature. Recycling food and other organic waste into compost provides a range of environmental benefits, including improving soil health, reducing greenhouse gas emissions (Ayeleru and Olubambi, 2021), recycling nutrients, and mitigating the impact of droughts.

Organic farmers optimise the growing conditions of crops by enhancing the natural fertility using compost, good water supply, creating diverse cropping systems and promoting natural enemies of pests, recycling organic materials and manures while denouncing the use of chemical pesticides and synthetic fertilisers.

A key part of the composting process is having an effective composting system in place using manure and other biomass wastes as a feedstock. Though manure is a rich source of nutrients and has been used as fertiliser since long time ago, uncomposted manure may contain weed seeds (Larney and Blackshaw, 2003) and disease causing germs (pathogens) that can be passed into your farm with the unbroken down waste, which also attracts flies and pause risks of contamination of food and drinks. Above all, the direct application of manure will burn plants due to its volatile chemicals and excess nutrients that imbalances plant growth (Grewal *et al*., 2006).

Therefore composting is a cornerstone of organic farming and has many benefits to the community and environment. Making compost is not only about providing soil and plants with a source of nutrients, it is an integral part of working organically and reducing waste (Rynk *et al*., 1992).

2. Why Compost?

Compost is a mixture of organic residues: manure, straw, farm residues, kitchen wastes and animal carcasses that have been piled, mixed and moistened to undergo at high heat decomposition temperature (45-55ºC), which is thermophilic (Larney *et al*., 2006; Michel, 2009). Compost as biofertilizer when applied to agricultural fields, it improves soil structure by increasing the enzyme activities and nutrients to the soil (Steger *et al*., 2007). Soil fertility, water-holding capacity, bulk density and biological properties are improved (Flavel and Murphy, 2006). Odors are reduced and fly eggs die due to the high temperatures occurring during microbial decomposition (Larney *et al*., 2006).

3. Compost vs Manure

Compost and manure are both organic waste materials in there composition however, manure is a raw organic waste from animal droppings, which is not fully composted and may contain bulk organic content with high loads of pathogenic microorganisms, which severly affect the helath of plants. Compost on the otherhand is a product of decompostion/composting process, which reduces the volatile organic content and pathogenic microorganisms. In compost, the nutrient content (C:N) ratio has been mentained/controlled as it is composed of straw, sawdust and other plant materials other than manure. As a result, compost is much more preferred than manure for its benifit to the plant and the environment. Different types of animal manure have different levels of macro-nutrients and, therefore, must be adequately composted for effective field use and proper application. Composting animal manure is an effective way to kill pathogens, decrease the bulk volume of manure and readly avilablity of nitrients to plants (Grewal *et al*., 2006).

Manure application on soils of croplands will allow the growth of intact weed seeds that pass through livestock feaces. Unlike manure, compost arrests the growth of few seeds of downy brome, false cleavers, foxtail barley, scentless chamomile, wild mustard and wild oat after 21 days of composting (Larney and Blackshaw, 2003). However, some weed seeds: green foxtail, redroot pigweed, round-leaved mallow, stinkweed and wild buckwheat found to be resistant for normal composting but, will stop germinating after 42 days of composting (Larney and Blackshaw, 2003). The other advantage of ccomposting over manure is that, it reduces about 50 to 65% of the volume and density of manure, which also reduces hauling costs (Wiederholt *et al*., 2009). Aapplication of livestock compost is more energy efficient than hauling raw manure. The energy ratio of raw manure to composted manure is 1.56-to-1 energy units, which is enough to offset the energy required to compost.

4. Feedstocks for composting

Organic waste is an inherent produce of nature and human activities in the form of solid or liquid waste biomass which can be collected from various sources: agriculture, industry, household and community wastes. Animal manure: cow, sheep, goat, horse and donkey, chicken, pig...) together with plant materials are good sources of compost.

Chicken manure is a rich source of nutrients and is best applied in fall or spring after it has composted. Similarly, cow manure, which has a 0.5-0.2-0.4 ratio, is composted beforehand for better results. Sheep manure has a high nitrogen content but lower ratio in the other macro-nutrients; however, its pellet size makes it a quick waste to compost. Horse manure takes longer and has similar content to cow manure but its larger size and the weed seeds in the animal waste takes much longer to age and compost in the process. Any type of manure can be benificial if applied properly. If you want to apply manure to your farm, compost the manure fully for at least six months or longer or add it raw and till it into the soil at least a season prior to planting (Rynk *et al*., 1992; Larney *et al*., 2006; Michel, 2009).

5. What are the requirments for composting?

For sustainable production of quality compost, we have to consider and use the following four conditions: site selection, aeration, moisture and nutrient content of the feedstock used for composting.

5.1 Site Selection

Based on space availability and volume of compost required, composting can be done either using Indoor Compost Bins: plastic storage bins, buckets, old wooden dresser drawers, wine crates, or other boxes (Vanderlinden, 2020) or in an open field that drains well but where runoff or leachate will not reach .

5.1.1 Indoor Compost Bins

This refer to a closed system where there is space limitation. More often, kitchen waste and food leftovers canbe used as feedstock to produce a compost and used for small gardens. Typically, closed bins have an open bottom to allow the nutrients in the developing compost to travel directly into the soil. Indoor compost bins have a removable top so that more compostable materials can be added. Depending on the material you build your bin, drill or punch small holes along the sides to allow airflow (or turn it manually for a hotter process). The holes or openings in the bin has to be small enough to prevent entry of rodents or any other animals of concern.

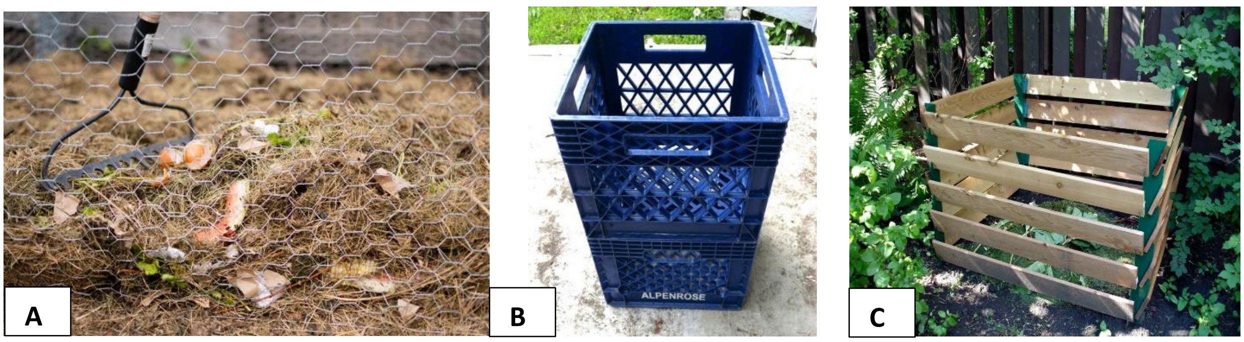

Figure 1. Chicken mesh wire (A), perforated plastic bin (B) and wood plate (C).

5.1.2 Open field

Open field is preferred for large quantity of composting for wider application. Ideal sites for open field composting are well-drained with slopes of 2 to 4% that consists of concrete or packed soil or gravel and drain into a containment pond. Windrows should be constructed parallel to the slope. This prevents the windrow from blocking runoff and allows implement access to the pad. Slopes exceeding 6 percent may be prone to erosion and may require other mechanical support to retain the compost (Agri Farming, https://www.agrifarming.in/windrow-composting-process-types-benefits).

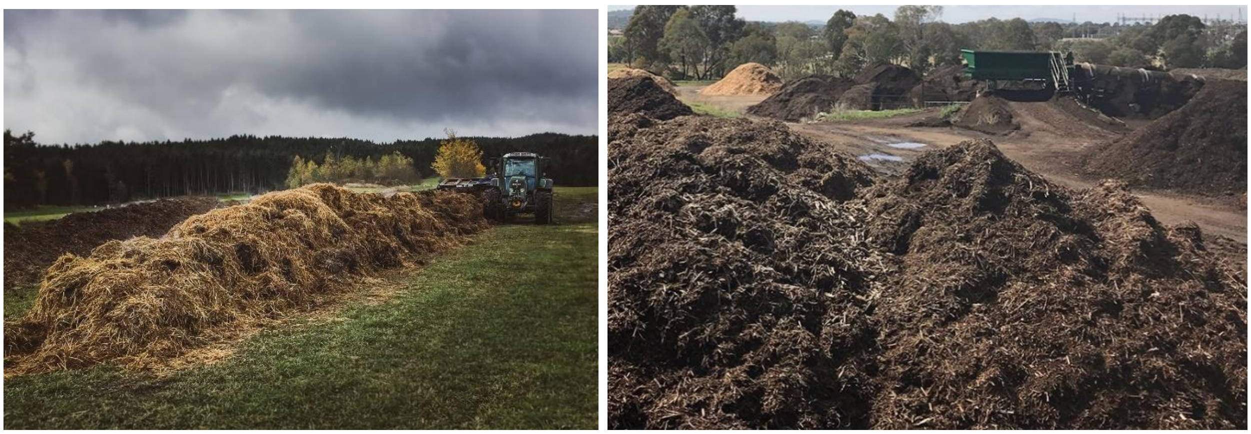

Figure 2. Open unpaved windrow composting. https://www.compost-systems.com/en/solutions/open-unpaved-windrow-composting).

5.2 Aeration

Once the organic waste materials are collected, mixed and piled together in a water protected non steepy flat surface, routine introduction of oxygen is required to stimulate aerobic microorganisms to feed on the organic components and convert the piled organic material to a fairly stable nutrient-rich soil amendment (Larney and Blackshaw, 2003). The microorganisms that transform manure into compost require oxygen for their energy-deriving chemical reactions. Less than 5 percent of oxygen within the pore space will turn the pile anaerobic (without oxygen), may create a rotten-egg smell and will slow the composting process. Aerobic conditions can be replenished by turning the pile (Rynk *et al*., 1992).

5.3 Moisture content

In composting process, water management is important because 40 to 65 percent of the pore space in composting materials should have water. Measuring devices can be used to monitor the moisture. To maintain the moisture content of the compost, water can be added by spraying it directly on the pile as required during turning process. The simple hand test method called the "wet rag test" can be done by squeezing the compost and feel its moisture content. If water drips out then, it is too wet. But, if the compost feels like a wrung-out wet rag, the compost has sufficient amounts of moisture (Rynk *et al*., 1992).

5.4 Temperature

Monitoring the pile temperature with a probe-type thermometer can indicate when to turn the pile. To efficiently compost manure, turn the pile when the temperatures drops below 110° F. Overall, after three to five turns, the manure should be composted. Temperature measurements has to be taken at various locations and depths of the pile. According to Michel (2009), compost windrows can be turned every 10 days or two weeks. This can minimize labor while creating a good-quality product.

Manure piles may exceed 160 ºF, which can destroy the beneficial microbes, causing a decline in microbial activity and slowing the process of composting. If this occurs, chances are the piles have too much nitrogen and adding of carbon making the piles smaller and digging holes in the pile are ways of cooling the pile (Carpenter-Boggs, 1999).

5.5 Nutrient content

The C/N ratio of bulking materials of plant origin varies greatly as well and for the same reasons as manures (Table 1). The windrow dimensions are dictated by the length of the pad and size of the turning implement. After a day or two, the pile should reach temperatures in excess of 120° F. Decomposing microorganisms typically have a C/N ratio of 5-10-to-1. The C/N ratio needs to be higher because approximately 50 percent of the metabolized carbon is released as carbon dioxide (Miller, 1996). Nitrogen can be lost when the C/N ratio is below 20-to-1, and due to the presence of volatizing ammonia. Adding carbon (straw or woodchips) can help alleviate the problem. On the other hand, if the carbon C/N ratio is more than 40-to-1 ratio, it immobilize nitrogen and slows the composting process (Coyne and Thompson, 2006).

Table 1. Carbon-to-nitrogen (C/N) ratio of common composting materials (Rynk *et al*., 1992).

Material	Ratio	Material	Ratio
Cattle manure	19:1	Corn silage	40:1
Polutry carcass	4:1	Sheep manure	16:1
Dairy Manure	20:1	Horse manure	30:1
	12:1	Wheat straw	127:1
Swine Manure			
Cattle Carcass	10:1	Corn stalk	68:1
Sawdust	442:1	Swine Carcass	14:1
Grass	17:1	Leaves	54:1
Clippings			
Turkey Litter	16:1	Woodchips	600:1

NB: After doing the hand held experiment using compost, dont forget to wash your hands!!!

6. Composting- Processes

The decomposition of organic waste biomass to produce compost takes about 21 days and it involves several reaction steps and activities.

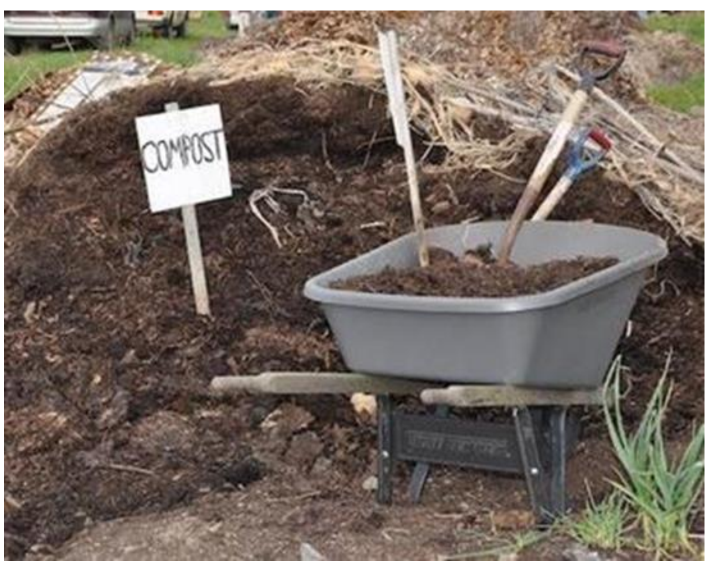

Figure 3. Animal manure compost.

6.1 Aeration Methods

Composting requires routine introduction of oxygen, which stimulates aerobic microorganisms that feed on the organic components and convert the piled organic material to a fairly stable nutrient-rich soil amendment (Larney and Blackshaw, 2003). Turning manure is essential to compost because it incorporates oxygen into the system, homogenizes the pile and breaks up clumps. Mixing allows more contact of manure with microbes. Producers have various ways to turn the pile. At commercial scale, there are two most common methods for turning compost: i) a windrow turner or ii} bucket tractor. Turners may be self-propelled or attached to a tractor or skid steer. Some front-mount turners clean pens and windrow the manure in the same pass. The benefit of this is that space and time are saved by eliminating the external pad and not hauling the manure out of the pen.

At small scale levels, manual turning using spade or forkhoe can be applied. Producers have many factors to consider when selecting a turner. Determining the amount of manure to turn is a good starting point.

Other ways to incorporate oxygen include using **passively aerated windrows** and **aerated static piles.**

- Passively aerated windrow systems require peat moss, wood chips or some type of material to be added to increase porosity.
- Perforated pipes can also be placed within the pile to allow airflow.
- No mechanical mixing is required, but the windrow should be constructed above 6 to 12 inches of compost or peat moss and covered by a layer of compost or peat moss. This covering insulates the pile and absorbs excess moisture.

NB: An aerated static compost pile is similar to passively aerated windrows but has fans that force air through the perforated pipes (Rynk *et al*., 1992).

6.2 Nutrient management

Manure composts improve soil physicochemical characteristics and are good sources of fertilizer for crop production. However, much of the nitrogen is tied up in complex organic compounds (immobilized) and is not immediately ready for plant uptake, whereas commercial fertilizers are predominantly plant-available. Cropland soils and compost should be tested for nutrients.

Nitrogen, phosphorus and potassium tend to be the most limiting nutrients required by crops (Coyne and Thompson, 2006).

Applications of compost must be based on crop needs. Manure applications usually are based on nitrogen needs for that crop. Most crops have a nitrogren-to-phosphorus (N/P) ratio of 7-to-1 to 10-to-1, whereas composted manure commonly has an N/P ratio of 1-to-2. Because of this, nutrient management plans may need to be based upon phosphorus management. This change in management can prevent nutrient loading and high levels of phosphorus that can accumulate when not properly managed and monitored (Spargo *et al*., 2006). Sampling and testing soil for nutrients can alleviate nutrient loading.

Crop and environmental benefits may not occur if the finished composted product is not tested and properly applied. Once cured, compost samples should be taken within the pile at various points and mixed thoroughly to account for variability. Samples should be tested as soon as possible or kept in cold storage until they can be sent to a laboratory for analysis. Approximately, 50:80:90 percent of nitrogen (N), phosphorus (P) and potassium (K) of the total nutrients are plant-available at the first growing season (Eghball and Power, 1999). However, studies showed that 15 percent of the total nitrogen in beef feedlot compost was plant-available at the first year and 8 percent of the nitrogen was mineralized by the second year (Eghball and Power, 1999). In composted livestock manure, 30% of the total phosphorus was mineralized in the first year and 70% by the second year, respectively. In another greenhouse experiment, 31% of the total potassium in compost was mineralized in the first year of application to the soil (Bar-Tall *et al*. 2004). In order to manage/control the fast miniralization of compost, the applications of compost fertilizer may be needed by supplementing with conventional fertilizers (Eghball and Power, 1999). The application of compost supplimented with nitrogen or phosphorus and conventional fertilizer yield equal or greater corn yields.

Compost should be applied with a calibrated spreader. The spreader is calabrate based on the the soil analyses and nutrient requiremments of the soil. This ensures that the proper amount of nutrients application and also lessens the chance of polluting.

6.3 Compost maturity and storage

After the heating cycles have subsided, compost usually is piled for storage while awaiting field applications. This month long or longer process is known as curing. Applying immature compost can cause issues that include malodors, insect swarms, nitrogen immobilization and phytotoxicity (Mathur *et al*., 1993; Steger *et al*., 2007).

Compost maturity is strongly related to microbial activities during the composting process. Producers have to assess compost maturity before storage by doing the following:

1. Laboratories sample analysis for nutrient content
2. Checking pile temperatures to ensure that the pile is near the ambient temperature
3. Using kits that give colormetric readings of carbon dioxide and ammonia emissions.

Then, store at ambilent/ room temperature.

7. CONCLUSION

Composting is an effective manure management tool that reduces volume, kills pathogens and weed seeds, and also improves soil health and fertility. While composting, manure needs to be managed properly. Soil and compost samples should be tested for nutrients content. The Carbon/Nitrogen ratios should be about 30-to-1, moisture content should be around 50 percent and air needs to be incorporated routinely by turning. This ensures that the pile will heat and convert to compost effectively within 21-30 days.

Over all, surface and ground water proximity are important for compost site selection. The compost site needs to be in an area not prone to contamination of groundwater by leaching or where leachate can run off to surface water.

Applying compost to the soil with a calibrated spreader ensures that crop yield goals will be met and reduces the chance of pollution.

REFERENCES

Agri Farming (2022). Windrow compostingprocess, types and benifits. https://www.agrifarming.in/windrow-composting-process-types-benefits (Accessed on 15th October, 2022).

Ayeleru, O.O. and Olubambi, P.A. (2021). Solid Waste Treatment Processes and Remedial Solution in the Developing Countries. In (Ed.) Karri, R. R., Ravindren, G and Dehghani, M.H. Soft Computing Techniques in Solid Waste and Wastewater Management. Pp. 495. https://www.agrifarming.in/windrow-composting-process-types-benefits.

Bar-Tal, A., U. Yermiyahu, J. Beraud, M. Keinan, R. Rosenbery, D. Zohar, V. Rosen and P. Fine. (2004). Nitrogen, phosphorus, and potassium uptake by wheat and their distribution in soil following successive, annual compost applications. *J. Environ. Qual.* 33:1855-1865.

Carpenter-Boggs, L. (1999). *Composting animal mortality resource notebook*. Minnesota Agricultural Experimental Station Miscellaneous Publication. 100-1999. Morris, Minn.

Compost Systems (2022). Open unpaved windrow composting (https://www.compost-systems.com/en/solutions/8open-unpaved-windrow-composting). (Accessed 4 Sept., 2022).

Coyne, M.S., and Thompson, J. A. (2006). *Math for soil scientists*. Pp. 176-190 and 199-208. Thomson Delmar Learning, Clifton Park, N.Y.

Eghball, B. and J.F. Power, J. J. (1999). Phosphorus- and nitrogen-based manure and compost applications: corn production and soil phosphorus. *Soil Sci. Soc. Am. J.* 63: 895-901.

Flavel, T.C. and Murphy, D. V. (2006). Carbon and nitrogen mineralization rates after application of organic amendments to soil. *J. Environ. Qual.* 35:183-193.

Grewal, S.K., Rajeev, S. Sreevatsan, S. and Micheal Jr. F. C. (2006). Persistance of *Mycobacterium avium* subsp. Paratuberculosis and other zoonotic pathogens during simulated composting, manure packing, and liquid storage of dairy manure. *Appl Environ Microbiol.* . 72(1):565-74. doi: 10.1128/AEM.72.1.565-574.

Larney, F.J., and Blackshaw, R. E. (2003). Weed seed viability in composted beef cattle feedlot manure. *J. Environ. Qual.* 32:1105-1113.

Larney, F.J., Buckley K. E, Hao, X. and W.P. McCaughey, W.P. (2006). Fresh, stockpiled, and composted beef cattle feedlot manure: nutrient levels and mass balance estimates in Alberta and Manitoba. *J. Environ. Qual.* 35:1844-1854.

Michel, F.C. Jr. (2009). On farm-scale composting. Midwest manure summit, Green Bay, Wis. March 24-25.

Miiler, R.M. (1996). Biological processes affecting contaminant fate and transport. In Pollution Science. pg. 77-91. I.L. Pepper, C.P. Gerba, and M.L. Bruddeau (eds). Academic Press, San Diego, Calif.

Mathur, S. P., Owen, G., Dinel, H. and Schnitzer, M. (1993). Determination of Compost Biomaturity. I. Literature Review. Biological Agriculture & Horticulture. *Intern. J. for Sustainable Production Systems* 10 (2): 65-85. doi.org/10.1080/01448765.1993.9754655.

Rynk, R., van de Kamp,M., Willson, G. B., Singley, M. E., Richard, T. L., Kolega, J. J., F.R. Gouin, F. R., Laliberty Jr., L., Kay, D., Murphy, D. W., Hoitink, H. A. J. and Brinton. W. F. (1992). *On-Farm composting handbook.* (Ed). R. Rynk.. Northeast Regional Agricultural Engineering Service, Ithaca, N.Y. Pp. 6-13, 106-113.

Spargo, J.T., Evanylo, G. K. And Alley.M. M. (2006). Repeated compost application effects on phosphorus runoff in the Virginia Piedmont. *J. Environ. Qual.* 35:2342-2351.

Steger, K., Sjögren, A. M., Jarvis, A., Jansson, J. K. and Sundh, I. (2007). Development of compost maturity and Actinobacteria populations during full-scale composting of organic household waste. *J. App. Microbiol.*. 103: 487–498. https://doi.org/10.1111/j.1365-2672.2006.03271.x.

Vanderlinden, C. (2020). Tips for Indoor composting. https://www.thespruce.com/tips-for-indoor-composting-2539618 (Accessed on 15th October, 2022).

Wiederholt, R.J., Rahman, S. and Ehni A. (2009). Energy efficiency of composting: A case study. In GIS applications in agriculture – nutrient management for improved energy efficiency. CRC Press.

Wortmann, C.C., Helmers,M., Mallarino, A., Barden, C., Devlin, D., Pierzynski,G., Lory, J., Massey, R., Holz, J., Shapiro, C. and Kovar. J. (2005). *Agricultural phosphorus management and water quality protection in the Midwest.* University of Nebraska-Lincoln Extension, Lincoln, Neb.   Reviewed and reprinted July 2016.

APPENDIX

COMPOSTING: Fundamentals and design considerations

APPSA biochar sub-Projec Team
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BIOCHAR AND COMPOST FOR SUSTAINABLE AGRICULTURE TO DRIVE OUT HUNGER!

1ST December, 2022

APPSA

INTRODUCTION

What is compost?

Compost is the product that results from the controlled decomposition of plant and animal (mainly manure) materials. It is not only a valuable nutrient source for plants, but also improves the quality of the soil.Compared with the uncontrolled decomposition of organic material, as it naturally occurs, composting results in an accellerated decomposition process with higher temperatures, and gives a product of higher quality. The high temperatures in the composting process kill most weeds, pests and disease-causing organisms

Benefits of compost

Compost contributes to an increase of the organic matter content of the soil, which in turn improves its structure, increases the soil's water holding capacity (and thus its drought mitigation), balances the pH, promotes microbial activity and can suppress soil-borne diseases. In addition, it has the following advantages:

• Compost increases the effect of (even small amounts of) animal manure when added together.

•Compost reduces deficiencies of trace elements.

•Compost also increases the availability of phosphorus to plants in soils rich in iron oxides that are common in Africa.

•Most mature composts have a pH of 6 to 8. Due to their balanced acidity, composts improve the availability of nutrients in soils.

•Compost helps avoid nitrogen losses in temporarily water-logged soils.

Objectives:

1to produce organic fertiliser from decomposition of waste biomass

Materials and Methods

In this process, five steps are involved:

Stteep 1: Collecting materials from non-contaminated sources

To make good quality compost, green and dry plant materials, animal manure, partially or fully decomposed organic materials, and water are used. As most crop residues are low in nitrogen, nitrogen rich sources such as leaves from green leguminous plants, shrubs and trees should be added to ensure sufficient nitrogen for the composting process. Whenever possible, plant materials should be composted together with (dissolved) animal dung, urine or slurry, or animal manure from stables and pens, as it accelerates the composting process and increases the compost's fertilizer value. Ash, saw dust, top soil, or fertilizers like ground phosphate or lime can be added in small quantities. Agro-industrial wastes like coffee pulps or husks can also be used. Avoid contaminants like chemical pesticides or heavy metals. All materials should be chopped into pieces 5 to 10 cm in length.or spread on the ground or used as livestock bedding before composting to get them bruised for better decomposition.

Composting process/ Methodology

Step 2: Mix and water the materials

For a good composting process, 1 part of fresh plant materials and manure are mixed with 2 parts of medium sized rough dry materials. During mixing, the materials should be well watered. Some methods suggest piling the materials in layers instead of mixing them. If too much fresh material is used, aeration of the heap will be poor. As a result the heap will start to smell and nitrogen will be lost. If too much dry material is used, the bacteria, which decompose the materials, will lack adequate food (nitrogen) and the composting process will not start. Very dry or woody materials are thus best left in the field as mulching material or used to cover the compost heap.

Step 3: Piling of the mixed materials

The materials are piled onto heaps of about 2 m wide, 4 m long and 1.2 m high. When a heap has reached its final size, it is covered with dry materials like grass in the dry season, or banana leaves during the rainy season to protect it from drying out. To determine the temperature during the composting process, a wooden or metal rod can be inserted into the heap (see further details in step 4 below). In dry climate, it is recommended to produce compost in pits 0.5 m deep.

Step 4: Checking moisture and temperature

Throughout the composting process, the conditions in the heap must be monitored temperature regularly. Two to 3 days after preparation of the compost, the first check should be made. If the pulled-out stick is warm, this indicates that decomposition by the bacteria has started. To check the moisture, the compost sample has to be collected and pressed in the hand. If it falls apart, it is too dry. If it smears, it is too wet. If the material keeps its form without dripping, it has the ideal moisture. If the stick is cool, it indicates that the conditions for decomposition are not ideal: The heap is either too dry inside or lacks nitrogen rich green material or manure. In this case, the materials need to be watered and/or remixed adding more green materials or manure to kick-start the process.

Stteep 5: Turning of the heap

When the temperature starts to decline after about 10 days, the heap needs to be turned and re-watered well. This procedure is repeated after 20 and 40 days at least, however the more frequent the turning, the faster the decomposition. Before each turning, the covering material is removed. After each turning, the heap is covered again. When the temperature in the heap does not rise anymore, the heap is going through the cooling phase, during which fungi decompose the dry material. At the end of the cooling phase a last turning is needed, before the compost goes through maturation by red compost worms. The riper the compost gets, the more it has a smell of forest soil.

Practical demonstration

Engage the participants in a practical demonstration of compost making: Obtain the different materials required for compost making together and practically demonstrate to the participants how compost is made.

RESULTS

Composting process with three distinctive phases

Properly made compost goes through three phases: the heating phase, the cooling phase and the maturing phase. Within three days after setting up the compost heap, temperature in the heap rises to 60 to 70 °C for two to three weeks (heating phase). The high temperature is a result of energy released by the bacteria during the decomposition of easily digestible materials.

After decomposition of the green plant material by the bacteria, the temperature in the compost heap declines slowly to 25 to 45 °C. Fungi then start the decomposition of straw, fibres and wooden material. As this decomposition process is slower, the temperature of the heap does not rise.

During the maturing phase, red compost worms and other soil organisms start to inhabit the compost heap. Nutrients are mineralised and humic acids and antibiotics are built up. At the end of the maturing phase the compost has lost about half of its original volume, has taken on a dark colour and the smell of fertile soil.

CONCLUSIONS

Compost heaps should be placed in a easily accessible and shaded place close to the fields and next to a water source. Tools needed for composting include a hand hoe, a machete (panga), a spade or forked hoe, a watering can, wheelbarrows, and a sharp stick or a compost thermometer to monitor the temperature changes in the compost heap. For watering, a watering can or a sprayer should be used rather than a bucket to ensure a good distribution of the water. Large scale production of compost can be made easier by using appropriate machinery such as for chopping raw materials and turning the compost heaps.

REFERENCES

1. Eghball, B., and J.F. Power. 1999. Phosphorus- and nitrogen-based manure and compost applications: corn production and soil phosphorus. Soil Sci. Soc. Am. J. 63:895-901.
2. Michel, F.C. Jr. 2009. On farm-scale composting. Midwest manure summit, Green Bay, Wis. March 24-25, 2009.

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