THE DECOMPOSITION SUBSYSTEM

Organic materials, litters, and residues (mainly of plant origin) are the precursors from which soil organic matter (SOM) is formed through decomposition and synthesis of new materials by soil organisms. Litter or residue quality play important role in the dynamics of soil organic matter in both natural ecosystems (a unit of biological organisation characterised by the integrated and largely self-maintained functioning of a diverse community of organisms with a range of physical environment) and intensively managed agroecosystems. Residue quality affects the rate of litter decomposition, nutrient release, level and quality of SOM. Detrital organic materials represent a bottleneck in nutrient cycling within an ecosystem. Its decomposition leads to release of essential nutrients for plant uptake. The importance of

Plant Residue and Residue Quality

Plant residue quality (PRQ) is a composite definition of the value of the residue as food to an organism. In other words, it is a measure of its decomposability (how easy it can be decomposed). Plant RQ embodies both physical and chemical criteria because both the physical, morphological and chemical attributes of litter determine the rate of decomposition. As food for soil organism, the residue must satisfy the physical (surface properties, texture etc.) and chemical (phagostimulant, growth factor and nutrition) requirements for ingestion or colonisation to occur.

Chemical Determinants of Plant Residue Quality

The chemical composition of plant residues that influence the activities of soil organisms in decomposing the residues may be divided into three main groups of compounds

Carbon and energy source**:** Carbon and energy are required in largest quantity by heterotrophic organisms to fuel their growth and activity. The bulk of the C and energy is stored in a variety of

polymeric compounds such as polysaccharides (starch, cellulose, hemicelluloses); lipids; protein; and aromatic polymers such as lignin or humus. The differences

Nutrient sources: These are elements other than carbon (such as N, P, K, etc).

Modifiers: Molecules that inhibit or stimulates decomposer activity by their chemical structure and are often (not always) active at relatively low concentration (e.g. polyphenols).

The concentration of C, N, lignin, polyphenols and their ratios in residues have been used to assess their quality, as well as for predicting nutrient release from the residue. The higher the C/N ratio, lignin content, and polyphenol content of residue the lower the rate of decomposition. In the tropical region, C/N ratio has been found to be the best predictor of N release. Nitrogen release increases with decreasing C/N ratio. When the C/N ratio is less than 30:1, N in litter will be mineralised under normal circumstances. Higher C/N ratio leads to immobilization. Nitrogen concentration can be used to predict N release of plant residue with N concentration <2% while the polyphenol/N ratio can be used for residue with N concentration <1%.

Phytotoxins in soil

Soil microorganisms produce a tremendous variety of organic substances during the decomposition of plant and animal residues, and, as numerous studies have shown, some of these substances are phytotoxic. While certain organisms secrete growth-stimulating substances, others produce growth-inhibiting substances.

COMPOSTING

Composting is the process of deliberate biological and chemical decomposition and conversion of organic or plant refuse and residues for the purpose of producing humified material referred to as compost under controlled conditions.

Importance of composting

Composting and compost application to soil is an effective means of residue management and essential nutrient management especially in tropical environment known for high rate of decomposition and nutrient leaching.

Composting also help the problems associated with the management of plant residues. During the process of composting, high temperature develops which helps in destruction of disease pathogens, pests, weed seeds and viruses. Menace of rodents breeding in scattered litters is prevented by composting plant residues. Composting is a means by which plant nutrients can be recycled with minimized loss because nutrient release from the compost can be synchronised with uptake by crop.

The end product of the composting process is a fertilizer with valuable properties and functions as soil amendment. Compost exhibits all the functions of soil organic matter. It improves both the physical and chemical properties of the soil – cation exchange capacity, soil structure, and soil tilt. It improves water holding capacity and crumb formation, promotes infiltration, protects against erosion and facilitates the spread and penetration of plant roots. Compost stimulates biological activity of the soil.

Compost acts as slow-release fertilizer thereby enhancing effective nutrient cycling. The slow release nature prevents loss of nutrients through leaching and enhances synchronization of nutrient release with uptake by the crop, and a long-term effect on soil fertility unlike other fertilizer sources. Composting products are odourless and easier to handle than the original materials from which the composts are made.

Principles of composting

Composting may be aerobic or anaerobic. In *aerobic composting*, living organisms, organic materials, moisture, ventilation and temperature are essential factors in. During the process of composting, the original structure of the organic materials is attacked by series of different organisms (decomposers) in succession beginning with bacteria, fungi, earthworms, isopods, millipedes and snails, followed by protozoan, collembolans and mites, and later by ants, beetles and predators. Bacteria and fungi are first colonizers while most of the higher organisms help in physical breakdown of the materials.

Composting materials

The chemical composition of the compost materials play significant role in the quality of the compost that is produced. The most important parameter to be considered is the ratio of carbon to nitrogen in the materials. The higher the C/N ratio, the lower the rate of decomposition. The C/N ratio of the compost mixture should not exceed 30:1. To achieve this, a mixture of 75% heterogenic plant refuse and 25% animal manure could be used. If the C:N ratio is low, N would be lost during composting. If the C/N ratio is higher than 35/1, the process will slow down and the optimum temperature will not be achieved.

In general principle, all organic materials are suitable for composting. However, separate treatment is required for feaces of carnivorous animals and excreta of human being.

Temperature

Hot heaps work very fast and efficiently and produce useable compost within short time in contrast to cold heaps. Cold composting methods take very long time and suitable only where little quantity is needed at a time and there is lot of space to make heaps.

Cold composting requires very little maintenance and it allows wider range of organisms. However, cold composting does not kill weed seeds or diseases.

Hot composting helps to maximize production but it requires high maintenance. To achieve sufficient range of temperature in hot heaps, balance of materials is crucial and all the materials have to be added at once. The temperature increases sharply reaching 60^{o} to 70^{o} C within the first 3 days, and continues this level for about a day before dropping slowly. The conversion process is most efficient at the hot phase with micro-organisms that thrive at high temperature multiplying while most weed seeds and agents of disease are destroyed.

Size of heap also affects the processes of composting. Too large heap however can overheat, leading to death of almost all the organisms. Turning of compost heap helps either re-enact the hot phase, or reduce built-up of excess heap depending on size of heap. Turning can be done after 2 to 14 days. During turning, materials on the peripheral are move to the centre where the temperature is normally the highest.

Aeration

Insufficient aeration of compost heap leads to death of the aerobic bacteria and anaerobic conversion of materials, rot or silage formation. Adequate air flow ensures fast decomposition and formation of good product. To achieve adequate aeration, materials should be prepared such that they do not stack too loosely or become compacted. No part of the composting heap should be further than 70 cm from the surface. Composting boxes could be made with air holes. Channels for gaseous exchange can be created by inserting post in the centre of the heap. Turning several times at the early stage of decomposition also helps in adequate aeration.

Moisture

Adequate moisture condition is important for the activity of microbial decomposers. At low moisture content (12-15%) the decomposition process stops. Moisture content between 40 and 60 % is ideal. Higher moisture condition may lead to putrefaction or cooking of compost materials at high temperature. Different compost materials require moistening in different ways. While materials like straw may require pre-soaking, soft and weak-structured materials like paper quickly become compacted thus preventing aeration. Layer arrangement of materials can also help out in such situation.

To ensure adequate moisture condition, compost can be constructed under shade, or covered with materials or life mulch (in cold composts), or be done in pit (especially in dry regions or during dry season). To prevent excessive moisture condition during raining season, compost heap can be covered with polythene; solid roof can be constructed over compost heap. Domed heap shape also allows rainfall to drain off.

Composting additives

Under condition of adequate moisture, temperature and aeration, microbial decomposers already present in the compost materials will multiply rapidly without any need for activator. Any substance with low C/N ratio or high level of available energy (such as dung, molasses, neem cake etc.) can serve as a natural activating agent. A little quantity of soil added would also ensure diverse numbers of microbial decomposers from soil organic matter to be involved in the process. However, additives may be added to composting heaps for specific purposes.

In order to avoid P fixation which is very high in tropical soil, phosphate rock of chemical composition recommended in organic farming is better added when required. In the absence of potassium-rich plant wastes, potash feldspar can be added if the aim is to produce compost rich in K.

Sometimes, lime could be added to achieve natural pH progression. In such situation, the lime, or other materials such as gypsum and ashes could be sprinkled thinly over each layer because too much alkali leads to high level of denitrification.

Methods of composting

Composting can be done in small, medium or large scale, depending on size of farm or production system, and availability of resources. However, the same principles apply in any case. Large scale aerobic composting systems tend to come in three main types.

Windrows systems where material is stacked in long piles generally up to 2-3m tall (or even higher when mechanically handled) and then turned on a regular basis to ensure adequate aeration of the substrate, and that materials which has been on the outside of the pile may experience the pathogen –killing temperatures achieved within the piles. Turning could be done either manually or mechanically. To avoid nutrient losses through leaching and runoff, composting is better done on concrete floor with drainage system that enable collection of runoff in a concrete tank. The water collected is nutrient rich and can be used for irrigation.

Static aerated pile. This can be made either by inserting lengths of tubing such as bamboo into the pile so that air may penetrate, or by forced aeration using tubing and air pumps. No turning of the compost occurs within the static piles

In-vessel systems. In comparison to traditional windrow composting, in-vessel composting techniques often represent more effective waste management options due to the reduced production of bioaerosols and leachate and the potential for better process control. In-vessel composting provides the greatest control of the compositing environment resulting in the most

rapid compost formation, but they are technologically complex and expensive and so are rarely suitable for large scale operations in developing countries.

Components of a composting plant may include magnets to remove metals hammer mill or shredders to reduce the size of materials before composting and sieve to remove inorganic, or large items that have not been humified during the composting process.

Small scale On-Farm Composting

Traditional on-farm composting is usually carried out in small scale. The methods however vary from place to place. Traditional methods include the heap method and the pit method and could be aerobic or anaerobic.

Example of anaerobic method is the *Indian Bengalore method*, a pit method used for composting night soil and refuse in region with scanty rainfall. *Passive composting of animal manure* naturally falls under the group of anaerobic method because the conditions for adequate aeration and optimum moisture is not met by just piling the refuse and leaving to decompose, as such anaerobic conditions normally develop within the pile.

The *Indian Indore method* is an example of aerobic decomposition through passive aeration. It could be carried out using the pit or heap method. In any case the principles of composting are maintained in the process. Pit method is better in less rainy condition. Otherwise, the pit would have to be sited on higher elevation or have a shed constructed to prevent rain. Heap method is more appropriate in raining season

Other methods include *the Chinese rural pit composting* method and *high temperature composts*. Rapid composting can be achieved by adhering to the principles of composting.

Some earthworms have the ability to improve organic waste by feeding on them and produce casts that are richer in nutrient content than the original waste. The system of compost production through this means is referred to as *vermicomposting*.