Nutrient Management in Organic Farming - Organic Fertilizers, Composting, and Nutrient Cycling

Gargi Kalita, Pratyasha Jonak Boruah, Rekhashree Kalita

Today's agricultural productivity is declining due to the loss of inherent soil fertility, which is a consequence of intensive agricultural practices aimed solely at maximizing production, causing significant damage to the agro-ecosystem. However, to meet the demands of the burgeoning population, productivity needs to be sustained with shrinking resources, following sound agro-ecological approaches. Organic agriculture is an agro-ecological system that prioritizes building and maintaining a fertile and healthy soil ecosystem by harnessing plant nutrients from various organic nutrient sources, such as bulky organic manures, concentrated organic manures, biofertilizers, crop residues, liquid organic manures, and seaweed extract. Organic approach of soil nutrient management nurtures and boosts biodiversity, and minimizes soil disturbance ultimately leading to improved soil physical and chemical properties and restoring inherent soil fertility to bear yield. By focusing on holistic nutrient strategies, organic agriculture can contribute to resilient farming systems that align agricultural production with ecological principles, supporting both environmental sustainability and food security.

Keywords: *Organic farming, Manure, Composting, Biofertilizer, Nutrient cycling*

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Introduction

By 2050, the global population is expected to reach 9.6 billion, with India's population projected to grow to 1.7 billion. To meet the increasing demand for food, India will need to produce 430 million tonnes of food grains, which is more than 60% of the total required to ensure food security (FAO, 2022). However, agriculture today faces numerous challenges, such as slowing growth rates, declining productivity, shrinking net cultivable area, overexploitation of groundwater, rising malnutrition, environmental pollution, and escalating production costs. These issues are not only lowering agricultural productivity but also threatening the availability and accessibility of food for a growing population. Given these challenges, there is a clear need for a shift toward agro-ecological farming practices. Agro-ecology focuses on preserving the ecological processes that are essential for crop production, like soil nutrient cycles and natural pest control, while also delivering broader societal benefits, such as healthier food and more attractive landscapes (Duru et al., 2015; Boeraeve et al., 2020). This approach embraces not only ecological but also socio-economic aspects of food systems, offering a holistic and sustainable path forward for farming. By promoting practices like organic and natural farming, as well as integrated crop management, agro-ecological farming can help boost food production while ensuring long-term sustainability in agriculture (Ravisankar & Kumar, 2024). Organic Agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved (IFOAM, 2008).

Healthy soil: The foundation of organic agriculture

Nutrient-rich soil is the cornerstone of organic agriculture, providing plants with the essential elements required. Healthy soil leads to increased crop productivity and enhances the quality of produce, improving not just taste, but also appearance and nutritional value. On the other hand, insufficient nutrients can stunt plant growth, reduce yields, resulting in poor harvests. Thus, optimizing soil health is the key foundation of organic farming. Organic agriculture enhances soil health by maintaining high levels of organic matter, promoting biological activity alongside balanced nutrient levels. Organic farming aims to "feed the soil to feed the crop"; ensuring nutrients and soil life are preserved through a long-term, whole-farm strategy based on nutrient budgeting (Barry et al., 2008; Chaithra & Scholar, 2024). It is estimated that organic manures and other sources can provide around 15 million tonnes of nutrients (Ravisankar & Kumar, 2024). Research indicates that organic farms often support a greater diversity of plants, insects, and animals than conventional farms (Bengtsson et al., 2005; Panday et al., 2024). Therefore, to optimize soil health, organic farmers must carefully manage a range of factors, such as soil, crop rotation, and manure to ensure a steady nutrient supply. This will not only maximize crop yields but also minimize environmental losses.

Nutrient sources in organic farming

Nutrient management in organic farming presents a unique challenge, as the use of inorganic fertilizers is strictly prohibited. To address this, organic farmers rely on several natural methods to maintain soil fertility. Here's a look at some of the primary nutrient sources in organic farming systems.

Manures

The term *manure* comes from the French word *manoeuvrer*, meaning "to work with soil." Manure refers to organic materials derived from animal, human, and plant residues, which contain plant nutrients in complex organic forms (Reddy, 1999). It plays a vital role in distributing essential nutrients like N, P, K, S, Mg etc. ensuring proper crop growth and development. The nutrient content of manure is influenced by various factors, such as type of animal, quality of bedding material, composition of the feed, as well as the conditions and duration of storage. These factors can significantly impact the effectiveness of manure as a nutrient source for crops. Moreover, since crops tend to absorb more nitrogen than phosphorus, applying manure to meet the crop's nitrogen needs can sometimes result in excess phosphorus in the soil. This surplus phosphorus can be lost through runoff and erosion, potentially contaminating nearby water sources (Wortman *et al.*, 2017). Therefore, careful management is essential to ensure that the nutrient supply is balanced, reducing the risk of environmental losses.

Classification of manures: On the basis of nutrient content per unit quantity, manures are broadly grouped into two classes:

- Bulky Organic Manures: Compost, Farmyard manure (FYM), Green manure, Sewage and Sludge
- Concentrated Organic Manures: Oilcakes, Bone meal, Blood meal, Fish meal, Guano

Table 1. Nutrient Content in various Organic Nutrient Sources

Sl. No.	Source of Nutrient	Nutrient Content (%)		
		N	P	K
1.	Compost	0.50	0.15	0.50
2.	FYM	0.50	0.20	0.50
3.	Vermicompost	3.00	1.00	1.50
4.	Castor Cake	5.50-5.80	1.80	1.00
5.	Mahua Cake	2.50	0.80	1.20
6.	Groundnut Cake	7.30	1.50	1.30
7.	Coconut Cake	3.00	1.90	1.80
8.	Bone meal	3.50	20.00-25.00	-
9.	Blood meal	10.00-12.00	1.20	1.00
10.	Fish meal	4.00-12.00	3.00-9.00	1.80

Bulky organic manures

Bulky organic manures are materials that have relatively low nutrient content per unit, meaning they must be applied in larger quantities.

Compost: Compost is one of the most widely used bulky organic manures, formed through a process known as *composting*. Composting involves the decomposition of plant residues and animal waste by both aerobic and anaerobic microorganisms, which helps break down the organic matter and lower the C: N ratio. Beyond providing essential plant nutrients, compost significantly enhances the physical, chemical, and biological properties of the soil (Amanullah et al., 2019; Ram et al., 2024). Compost can also help eliminate the incidence of diseases caused by harmful microbes in the soil. It supports the growth of beneficial bacteria that improve soil health and reduce the likelihood of crop contamination by pathogens (Paul & Mandi, 2025). Compost can be made from various waste materials, including cereal straws, farm weeds, crop residues such as sugarcane leaves and stalks, groundnut husks, and even vegetable and fruit waste. Compost generally contains 0.5% Nitrogen, 0.15% Phosphorus, and 0.5% Potassium in its nutrient profile (Roy et al.,2024). By incorporating compost into the soil, farmers can improve crop productivity while maintaining the health and sustainability of the land.

Compost can be prepared by the following methods:

Indore method: The Indore Method of composting was developed by Howard & Ward at the Indian Institute of Plant Industry, Indore. In this method, organic materials such as animal bedding and waste are spread in the cattle shed, where they become soaked with urine and mixed with dung. Every day, the soiled bedding is removed and arranged into a layer about 15 cm thick in a suitable composting site. The layering process continues for about two weeks. After this period, a thin layer of well-decomposed compost is sprinkled over the top, and the pile is turned and reformed (Reddy, 1999). The addition of old compost acts as an inoculum to help break down the new material. The heap is then left undisturbed for about a month to allow further decomposition. Thereafter the compost is thoroughly moistened and turned regularly, ensuring proper aeration, moisture distribution and preventing compaction (Roy et al., 2024). The final product is ready for use in another month.

Coimbatore method: The Coimbatore Method is a pit/ trench-based composting technique developed by Manickam in 1967. These trenches are typically 10-15 feet long, about 3 feet wide and 3 feet deep (Roy et al., 2024). The composting process begins by laying a layer of organic waste materials in the pit. To aid decomposition, the material is moistened with a solution of 5-10 kg of cow dung mixed with 2.5-5 liters of water. Additional layers of organic waste are added on top, with the pile reaching up to height of 0.75 m. The pit is then plastered with wet mud and left undisturbed for 8-10 weeks. After this period, the mud is removed, the material is moistened with water and the compost pile is turned and reformed into a rectangular heap. The compost is then left undisturbed under shade until it is ready for use (Reddy, 1999). This method produces well-aerated compost with a balanced nutrient profile and a rich population of beneficial microorganisms, which help improve soil health and support plant growth (Roy et al., 2024).

Bangalore process: The Bangalore Method of composting was developed in 1939 by Acharya & Subramaniyan at the Indian Institute of Science, Bangalore. This method utilizes anaerobic decomposition techniques (Bhattacharyya, 2024). In the Bangalore method, dry organic waste material is spread in a pit to a thickness of about 25 cm. A thick suspension of cow dung mixed with water is then sprinkled over the waste to moisten it. Afterward, a thin layer of dry waste is laid over the moistened layer. The process continues in alternating layers of dry waste and cow dung suspension until the material rises to about 0.5 meters above ground level. Once the pit is filled, it is left exposed without any covering for 15 days to allow initial decomposition. After this period, the material is turned, plastered with wet mud, and left undisturbed for around five months or until it is needed. The anaerobic conditions in the pit foster the breakdown of organic material, and the final compost produced is rich in nutrients, ready for use in enriching the soil.

Vermicomosting: Vermicomposting is a process where organic waste is broken down with the help of earthworms and the end result is a rich, nutrient-packed substance called vermicompost. Earthworms play multiple roles in this process they physically aerate, crush, and mix the materials, chemically break down organic matter, and biologically stimulate the process of decomposition through their activity (Reddy, 1999). Rajkhowa et al., 2003 reported that a mixture of biomass to FYM at 60:40 ratio was the best to produce quality vermicompost within 60-70 days in the humid subtropics of India. Along with major nutrients, vermicompost is also rich in micronutrients, plant hormones like auxins and cytokinins, enzymes and vitamins. Microbial load was also found to be higher in vermicompost (Rajkhowa et al., 2003). Earthworms are classified into three types based on their habitat and ecological role: epigeic, anecic, and endogeic. The most common species used in vermicomposting are from the epigeic category, such as *Eisenia andrei* and *Eisenia foetida*. These worms are surface feeders with a high bioconversion rate (Kahlon *et al.*, 2020). In India, popular species for vermicomposting include *Eisenia foetida, Perionyx excavatus, Eudrilus eugeniae*, and *Lampito mauritii*, among others (Rajkhowa & Kalita, 2003).

Vermiwash: Vermiwash is a natural liquid produced through the process of vermicomposting (Thakur & Sood, 2019; Gudeta et al., 2021). It contains a variety of beneficial substances, including plant hormones, mucus, enzymes, vitamins, proteins, macro and micronutrients, as well as a wide range of microbes (Nadana et al., 2020). In addition to being a powerful fertilizer that boosts crop productivity, vermiwash also has its uses in disease suppression and pest control, mostly due to its antimicrobial and anti-pest properties (Gudeta et al., 2021).

Farmyard manure: Farmyard manure (FYM) is a traditional and widely used type of organic fertilizer made from a mixture of solid (dung) and liquid (urine) waste from farm animals, along with bedding materials (litter) and leftover fodder. It's one of the oldest and most popular forms of manure.

Trench method of FYM preparation: The trench method for preparing FYM was recommended by C.N. Acharya to minimize nutrient losses during the process. In this method, trenches of about 6-7.5 m, 1.5-2 m width, and 1 m depth are dug. To absorb the cow's urine, bedding materials are mixed with soil and placed in a shed. The following morning, the urine-soaked bedding and dung are collected and added to the trench. A section of the trench is left open at one end to allow for daily collection. The trench is filled until the pile reaches a height of 45-60 cm above ground level, after which the heap is shaped into a dome and coated with cow dung and earth slurry. This process is repeated until the first trench is completely filled, at which point a second trench is dug. After about 4-5 months from plastering, the manure is ready to use. Additionally, gypsum is used in cattle sheds to supply calcium and sulphur, absorb urine, and prevent the loss of urea through volatilization. The use of superphosphate also helps reduce losses and increase the phosphorus content of the manure (Dutta et al., 2025).

Sewage and sludge: In urban areas, human waste is flushed away with large amounts of water through a sewage system. Sewage consists of two main components: the solid portion, known as sludge, and the liquid portion, called sewage water. To treat sewage, it is typically allowed to sit in settling or septic tanks where the solid matter is separated, and the organic matter undergoes preliminary fermentation and oxidation. This helps reduce the C: N ratio in the sludge. Sludge generally contains high amounts of N and P but low K. The liquid sewage water can be used for irrigation purposes (Reddy, 1999).

Green manure: Green manuring is the practice of ploughing or incorporating undecomposed green plant material into the soil to improve its physical properties. The manure obtained from this process is called green manure (Das, 1993). This method involves growing fast-growing crops, which are then ploughed under to enrich the soil. Green manure crops not only add organic matter to the soil but also provide additional nitrogen, especially if the crop is a legume. Research shows that a green manure crop, around 40-50 days old, can supply up to 80-100 kg of nitrogen per hectare (Paul & Mandi, 2025).

Crops generally used for green manuring

Non-leguminous crops: These crops mainly add organic matter to the soil but do not contribute nitrogen. They are used for green manuring on a limited basis. Examples include: Mustard, rye, oats, buckwheat etc.

Leguminous crops: Legumes are more beneficial for green manuring since they not only provide organic matter but also fix nitrogen in the soil, improving soil fertility. Common leguminous green manure crops include: **Suhemp** (*Crotalaria juncea*), **Dhaincha** (*Sesbania aculeata*), **Berseem** (*Trifolium alexandrinum*) etc.

Characteristics of green manure crops

- A green manure crop should be suited to the local climate and soil conditions in which it is to be sown.
- The crop should haveprofuse leaves.
- The crop should grow quickly during its early life cycle and must be short duration.
- For legumes, a good nodular growth habit is essential for effective nitrogen fixation.
- The green manure crop should be able to establish itself even on poor or depleted soils.
- The green manure crop should have deep root system.
- Green manure crop should have high water use efficiency.
- The green manure crop must be a non-host for crop related pests and diseases.

Methods of green manuring

In-Situ green manuring: This method involves growing green manure crops directly in the same field where they will be buried for soil enrichment. It's also called *on-farm green manuring*. The seeds of green manure crops are typically sown in May-June, right after the first monsoon rains. Once the crop reaches the flowering stage, it is ploughed back into the soil. Most green manure crops need about 6-8 weeks to flower, with crops like *Dhaincha* (6-8 weeks old) and *Sunhemp* (4-5 weeks old) being ideal for burial. It is important that the soil has enough moisture when the crop is buried to help with its proper decomposition. After being buried, the green manure crops left to decompose for about 3-4 weeks before planting the next crop. This method is especially common in the north and south of India, where rice is the primary crop, as part of the country's standard cropping practices (Paul & Mandi, 2025).

Green leaf manuring: Green leaf manuring involves bringing in green leaves and young twigs from other areas to be buried in the field as fertilizer. These leaves and twigs come from various shrubs and forest plants and are mixed into the soil before planting of the crops. Plant species commonly used for this purpose, include: Glyricidia (*Glyricidia maculata*), Wild dhaincha (*Sesbania speciosa*), Neem (*Azadirachta indica*), Karanja (*Pongamia pinnata*), Wild indigo (*Tephrosia purpurea*) etc.

Concentrated organic manures

Concentrated organic manures are rich in nutrients, meaning smaller quantities are required to meet the nutritional needs of plants. These manures are particularly valued for their nitrogen content (Reddy, 1999) and are often referred to as organic nitrogen fertilizers.

Oilcakes: Oilcakes are the byproducts left after oil is extracted from oilseed crops. The remaining solid mass is dried and can be used as manure. Because oilcakes are rich in N, P and K, they serve as a valuable alternative to chemical fertilizers. After being applied to the soil, the nutrients in oilcakes become available to crops within 7-10 days through mineralization (Lee, 2010). Oilcakes can be divided into two categories:

Edible oilcakes: These oilcakes are safe for feeding to livestock. Examples include: Coconut cake, mustard oil cake, groundnut cake etc.

Non-edible oilcakes: These oilcakes are not suitable for animal feed and are used solely for fertilizing the soil. Examples include: Castor cake, mahua cake, neem cake etc.

Blood meal: Blood meal is a byproduct derived from slaughterhouses, made by drying and grinding animal blood. It is particularly valued for its high nitrogen content (10–13%) compared to other organic sources. Blood meal acts as a **slow-release fertilizer** (Panday et al., 2024) and can be used effectively on a wide range of crops and across different soil types.

Bone meal: Bone meal is made from the carcasses of animals, typically sourced from slaughterhouses and meat processing industries. It is a rich source of phosphorus and calcium ranging about 15-27% and 22–33% respectively (Załuszniewska & Nogalska, 2022). Bone meal also contains small amounts of nitrogen (1–4%) and trace minerals, including collagens (Panday et al., 2024). The glue extracted from bones has commercial value, while the remaining residue, in powdered form, is used as manure or cattle feed. Bone meal is a slow-acting fertilizer and is particularly beneficial for acidic soils and long-duration crops.

Fish meal: Fish meal is made from non-edible fish carcasses, typically after the fish oil has been extracted. It is available in various forms, such as dried fish, powder, or meal. Offering relatively high levels of nutrients, including nitrogen (10%) and phosphorus (6%), fish meal serves as an excellent organic fertilizer (Hartz & Johnstone, 2006).

Guano: Guano is a mixture of excreta and decayed remains of sea birds, rich in nitrogen and phosphorus. It is collected from islands as well as from the ocean floor. Another form of guano, called fish guano, is made from the refuse left over after fish oil extraction in factories, which is then dried and used as manure. Both types of guano have a similar impact on soil fertility and crop growth, providing essential nutrients for plant development.

Biofertilizers

Biofertilizers are organic products that contain specific microorganisms in concentrated form, typically derived from plant root nodules or from the rhizosphere soil. These microorganisms play a crucial role in enhancing soil fertility by either fixing atmospheric nitrogen through symbiotic relationships with legume roots, or through non-symbiotic processes. They also help transform essential soil nutrients, such as phosphorus, zinc, copper, iron, and sulphur, from non-usable forms into ones that plants can readily absorb (Balasubramanian *et al.,* 2013). The biofertilizers thus improve nutrient availability and accessibility to plants, ultimately boosting their nutrient absorption capacity (Abbey et al., 2019; Chaithra and Scholoar, 2024).

Biofertilizers are classified as:

Nitrogen fixing bacteria

- Symbiotic N fixers: Rhizobium
- Non-symbiotic N fixers: Azotobacter, Azospirillum, Azolla, Blue green algae.

Nutrient mobilizing bacteria

- Phosphorus solubilising bacteria (PSB)
- Potash solubilising bacteria (KSB)
- Vesicular arbuscular mycorrhiza (VAM)

Rhizobium: Rhizobium is a symbiotic, aerobic bacterium found in the soil that fixes atmospheric nitrogen in a symbiotic relationship with leguminous plants. These bacteria reside in the root nodules of plants belonging to the family Leguminosae. Rhizobium is capable of fixing up to 300 kg of nitrogen per hectare per year in various leguminous crops. Additionally, it can leave behind residual nitrogen in the soil, benefiting the succeeding crops (Barooah et al., 2025).

Azotobacter: Azotobacter is a group of free-living, heterotrophic, nitrogen-fixing bacteria from the family **Azotobacteriaceae**. It is typically used as a biofertilizer for non-legumes such as rice, cotton, vegetables, sugarcane, sweet potato, and sweet sorghum (Barooah et al., 2025). In addition to nitrogen fixation, azotobacter produces plant hormones like vitamin B complex, gibberellic acid, NAA and IAA, which can promote plant growth (Chaithra and Scholoar, 2024). Azotobacter can fix about 20–30 kg of nitrogen per hectare per year.

Azospirillum: Azospirillum is an aerobic, free-living nitrogen-fixing bacterium belonging to the family Spirilaceae. It forms a symbiotic relationship with plants that use the C4-dicarboxylic pathway for photosynthesis, such as sugarcane, maize, sorghum, bajra, and other cereals like wheat, rice, and barley (Yasuda et al., 2022; Barooah et al., 2025). Azospirillum can fix about 20 - 40 kg of nitrogen per hectare.

Azolla and blue-green algae: Azolla is a type of water fern commonly found floating in stagnant ponds, tanks, ditches, and channels. It is often seen in rice fields, where it forms a symbiotic relationship with blue-green algae (*Anabaena azollae*). This alga resides in the epidermal cavity on the lower side of Azolla's leaves and helps in fixing atmospheric nitrogen. This mutualistic association between *Azolla pinnata* and *Anabaena azollae* is known as the Azolla-Anabaena Complex. The algae fix nitrogen for the Azolla plant, and in return, the plant provides the algae with a habitat and nutrients. This complex has significant potential as a biofertilizer in agriculture, especially in rice cultivation. Additionally, it can be used for bioremediation in areas polluted with heavy metals (Akhtar et al., 2020). The Azolla-Anabaena complex can add about 30 -40 kg of nitrogen per hectare per year.

Phosphorus Solubilizing Bio-fertilizer (PSB): Around 75% of applied phosphorus in the soil becomes fixed and unavailable for plant uptake. However, phosphorus solubilizing bio-fertilizers (PSB) like Phosphobacterin can help convert these fixed forms of phosphorus into soluble forms, making them available for plant absorption. The PSB group includes various bacterial genera such as *Pseudomonas, Bacillus, Rhizobium,* and *Enterobacter,* along with fungi like *Aspergillus* and *Penicillium* (Barooah et al., 2025). These bio-fertilizers can be effectively applied to a variety of crops, including cereals, pulse crops, oilseeds, and vegetables.

Potash solubilizing bacteria (KSB): Potash solubilizing bacteria play a crucial role in providing potassium in high amounts to plants. These bacteria help break down silicate minerals and release potassium through various mechanisms such as the production of organic and inorganic acids, acidolysis, polysaccharides, complexolysis, chelation, and ion exchange reactions (Etesami et al., 2017). Beyond this, KSB also produce beneficial compounds like amino acids, vitamins, and growth hormones such as IAA and gibberellic acid, all of which contribute to improved plant development (Jayaswal et al., 2022). Several bacterial species, including *Acidothiobacillus ferrooxidans, Paenibacillus* spp., *Bacillus mucilaginosus, B. edaphicus,* and *B. circulans,* are known for their ability to solubilize potassium-bearing minerals like biotite, feldspar, illite, muscovite, orthoclase, and mica (Etesami et al., 2017). Therefore, the production and use of biological fertilizers enriched with KSB could be a highly effective and sustainable approach for enhancing soil fertility in organic farming systems.

Endomycorrhiza or VAM fungi: Vesicular arbuscular mycorrhiza (VAM) is a symbiotic relationship between certain fungi and the roots of higher plants, found in about 80% of plant families (Sadhana, 2014). VAM fungi form specialized structures known as vesicles and arbuscules, which facilitate the transfer of essential nutrients like phosphorus from the soil to the plant. In addition to improving phosphorus uptake, this fungal association offers several other benefits to plants, including increased root and shoot growth, enhanced water uptake, improved plant tolerance to both biotic and abiotic stress (Barooah et al., 2025).

Crop residues

Crop residues which are generated during the harvest of agricultural crops are often repurposed in various ways. They can be used as animal feed, mulch for soil, manure, thatching for rural homes, or even as fuel for both domestic and industrial needs. These residues are rich in carbon (40-45%), nitrogen (0.6-1%), phosphorus (0.45-2%), potassium (14-23%), and essential micronutrients that are important for plant growth (Wang et al., 2020). Crop residues can be returned to the soil to recycle nutrients and enhance its overall health—improving its physical structure, chemical balance, and biological activity. When applied to the soil, they help reduce erosion and boost water retention. In addition, some crop residues naturally prevent the growth of weeds through an allelopathic effect, which reduces their access to sunlight, alters soil temperature, and releases chemical compounds that hinder their development (Ram et al., 2024).

Crop rotation

Crop rotation is an age-old farming practice that provides a range of benefits, including reduced weed and pest problems, less nutrient depletion, and better soil health. By rotating different crops, farmers can help maintain soil fertility and organic matter, and boost overall crop yields (Scavo & Mauro Micale, 2021). This practice also helps prevent the spread of soil-borne diseases (Ram et al., 2024). Incorporating legumes like beans, alfalfa, or clover into the rotation offers a natural nitrogen boost for subsequent crops. This is due to their ability to fix nitrogen in the soil, reducing nitrogen loss compared to planting non-legume crops. Changing the sequence of crops also disrupts the life cycles of pests and pathogens, which helps prevent them from building up and targeting specific plants.

Organic soil amendments: Organic amendments are among the most effective and environmental friendly ways to improve soil fertility. Natural materials like rock phosphate and limestone are commonly used to enrich the soil. These minerals not only provide essential nutrients like phosphorus, calcium, and magnesium, but they also help adjust soil pH, making the environment more conducive for plant growth (Zapata & Roy, 2004). Since these amendments are derived from natural sources, they avoid the environmental harm associated with synthetic fertilizers, such as the greenhouse gas emissions generated during their production. Beyond providing nutrients, organic amendments also enhance soil structure, improve aeration, and help combat erosion, creating a healthier and more resilient soil system.

Liquid organic manure: Liquid organic manure is a blend of animal waste and organic materials, often mixed with water to create a natural fertilizer for agriculture. It can be concentrated by aging it in a slurry pit. Developed in the 20th century as an alternative to traditional fermented manure, liquid organic manure contains beneficial microbes that help in processes like phosphate solubilization and nitrogen fixation

(Ahmed et al., 2025). One of the key advantages of liquid organic manure is its quick availability to plants, as it easily disperses in water, making it more accessible than bulky solid organic fertilizers.

Different types of liquid manures and their preparations are given below:

Jivamrut: Mix 10 kg cow dung, 10 L cow urine, 2 kg jaggery, 2 kg flour of any pulse grain and 1-kg fresh forest soil in 200 L water. After 5 to 7 days of fermentation, regularly stir the solution three times a day. Use in one acre with irrigation water. It can be applied straight to the soil or in combination with irrigation water prior to seeding and then again 20 and 45 days later.

Beejamruth: Beejamruth is a mixture of cow milk, cow dung, cow urine, lime, and water. It is used for seed treatment, which helps in better germination, establishment, enhance growth and productivity of the crops.

Panchgavya: About 3 L cow urine, 5 kg fresh cow dung, 2 L cow milk, 2 L curd, 1 kg cow butter oil are mixed thoroughly and fermented for 7 days, stirring twice daily. Spray 3 L of panchgavya over the soil after diluting it in 100 gallons of water. Approximately 20 liters of panchgavya per acre are needed for soil application with irrigation water.

Seaweed extracts

Seaweed extracts are utilized as soil amendments because they have the ability to enhance plant growth by promoting seed germination, root development, leaf quality, and yield. By controlling gene expression for nutrient uptake, this amendment feeds the soil and plants. It also strengthens the soil’s structure and increases plants’ resistance to disease and biotic and abiotic stresses (Paul & Mandi, 2025).

Nutrient cycling in organic farming

Nutrient cycling is the process that encompasses the movement of nutrients from physical environment to living organisms and then returns to the environment. In agricultural systems, this cycle serves as a link between crops and the broader environment. A key part of this cycle is soil organic matter, which plays a central role in nutrient availability to plants. When plant residues and manure decompose, they release nutrients like nitrogen, phosphorus, sulphur, and boron, which plants can then absorb. This cycle repeats as organic matter breaks down, releasing essential nutrients for plant growth (Bierman & Rosen, 2005). Organic farming systems are typically characterized by crop rotations with high spatial and temporal vegetative diversity, the use of legumes, and limited use of synthetic fertilizers. These practices enhance soil health, microbial diversity, and nutrient dynamics (Lynch, 2015). Since organic systems depend on natural inputs like compost and manure, and the mechanical control of weeds, nitrogen losses through surface runoff and leaching tend to be low. However, this can lead to challenges with nutrient availability, especially if nutrients don't match crop needs, which can reduce yields and increase nutrient and sediment loss. Phosphorus losses, in particular, can occur when manure use exceeds crop demands, and the lack of chemical weed control increases the risk of erosion (Smukler et al., 2012). On the whole, organic farms tend to have better nutrient recycling, lower nutrient budgets, and greater nutrient use efficiency than conventional farms, as they rely less on external inputs (Nowak et al., 2015). Thus, a better understanding of the soil, agronomic, and agro-ecological effects of organic farming practices, along with their trade-offs in terms of productivity, can ultimately enhance nutrient cycling and improve efficiency of the organic farming systems.

Conclusion

The Organic farming stands as a sustainable and environmentally conscious alternative to conventional agricultural practices. There are a variety of ways through which organic agriculture builds soil fertility and enhances crop productivity. Besides most of the nutrient sources are available locally and the processes for production are also simple and environment friendly thus can be adopted by the farmers widely. Organic manures release nutrients more slowly than inorganic fertilizers, making their effects last longer. This slow decomposition helps increase the soil's organic matter, which is crucial for improving soil fertility. By enhancing the soil's ability to retain nutrients, maintain structure, and hold water, organic manures contribute to healthier soil and better plant growth. This approach not only preserves natural resources but also aligns with the broader goals of climate resilience, climate change mitigation and ecological sustainability. However, fully relying on organic farming or solely using organic sources may not achieve the desired results in short term. This is because the slower nutrient release from organic materials can prevent plants from getting the essential nutrients they need during the critical periods of growth, particularly during the vital yield-forming stages. Thus organic nutrient sources, although are rich in nutrient but cannot totally replace chemicals or inorganic fertilizers and so to boost the crop productivity the integration of both chemicals and organic nutrient sources needs to be embraced.

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