Chapter 3
Organic Farming for Sustainable Soil Use, Management, Food Production and Climate Change Mitigation

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Abstract Organic farming or organic agriculture has been adopted as a new and sustainable agriculture technology due to its environmentally friendly nature and healthy produce. It is an efficient technology to conserve soil fertility and health, improve crop yield and quality and reduce carbon concentrations in the atmosphere. It is more efficient in its use of non-renewable energy and has less detrimental effects on water quality and biodiversity. Different strategies are employed in organic farming for crop production. It uses biosolids in organic manures and amendments and crop rotations, mulching, non-synthetic fertilisers, zero tillage, integrated nutrient, pest management, etc., for crop management and productivity.

Keywords Soil health · Carbon sequestration · Soil fertility · Soil nutrients

3.1 Introduction

Organic farming refers to an agriculture system that relies on green manures, biofertilisers, plant growth-promoting bacteria, integrated pest management (IMP)/biological pest control (integrated pest management (IPM)), integrated nutrient management (INM) and zero or minimum tillage, mulching and crop rotation. It is a practice that entails the routine plant cultivation and animal rearing (Trewavas, 2001). Biosolids like organic manures and amendments along with biopesticides are among the biological materials and fertilisers used in this operation (allelopathic

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and plant growth-promoting bacteria). It avoids using synthetic chemicals to preserve land biodiversity and ecosystem equilibrium, reducing emissions and waste production (Hussain & Farooqi, 2021). To put it another way, organic farming is a technique that includes caring for and growing of crops without the use of chemical fertilisers and pesticides (Hole et al., 2005) and no production and involvement of genetically modified organisms (Heckman, 2006).

As organic farming relies on livestock manures, off-farm organic wastes, mineral grade rock additives, crop residues, crop rotation, biological system of nutrient mobilisation and plant preservation to the greatest degree possible, rather than conventional inputs (such as hormones, chemical fertilisers, feed additives and so on), it is the most preferred for agriculture nowadays. It has numerous advantages, i.e. it encourages and improves biodiversity, biological cycles and soil biological activity. Crop substitution, renewable fertiliser, organic wastes, natural weed management, mineral and rock treatments are also an example of ecologically balanced farming values. Pesticides and fertilisers are used in organic cultivation if they are deemed safe, while petrochemical fertilisers and pesticides are avoided (Barton, 2018; Palaniappan & Annadurai, 2018).

3.2 Need for Organic Farming

There is an increased need for organic farming due to the following reasons (Lammerts van Bueren et al., 2011; Macilwain, 2004; Stolze & Lampkin, 2009):

1. The organic food market is rapidly expanding and is highly profitable.
2. Food quality and environmental protection.
3. The enhancement of human wellbeing.
4. Organic goods have a rich flavour.
5. Analytical authentication ensures that the commodity is of a high standard.
6. The preservation of agricultural diversity.
7. Non-use of drugs, antibiotics and hormones in agricultural goods.

3.3 Key Aspects of Organic Farming

The following are the key features of organic farming (Altieri et al., 1983; Mäder et al., 2002; Pugliese, 2001) (Fig. 3.1):

1. Use organic content to protect soil health while still promoting biological development.
2. Use of soil microorganisms to provide crop nutrients indirectly.
3. Legumes are used to fix nitrogen in soils.

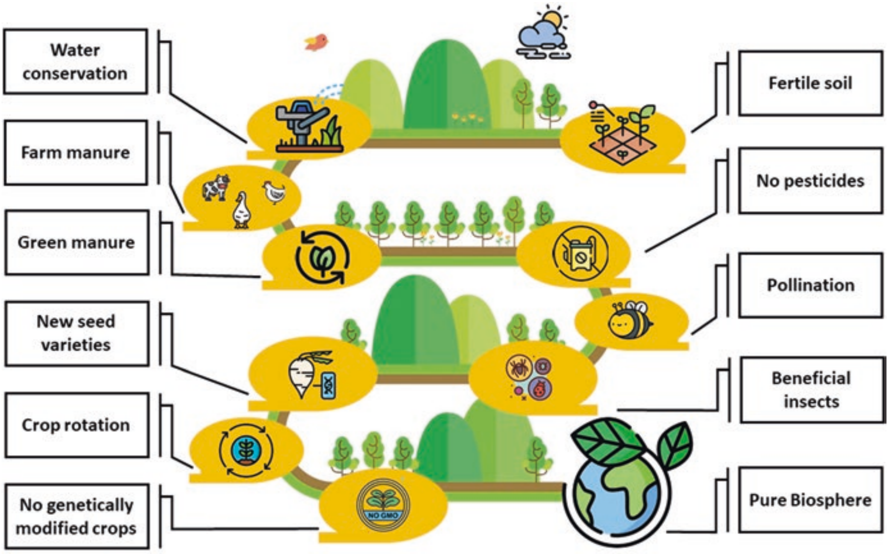

Fig. 3.1 Benefits and prospects of organic farming

4. Weed and pest management using crop rotation, environmental variation, natural pests, organic manures and appropriate chemical, thermal and biological action, among other approaches.
5. Animal husbandry, including shelter, diet, hygiene, rearing and breeding.
6. Environmental stewardship, including the preservation of natural ecosystems and biodiversity.
7. Development of natural crops.
8. Development of natural animals and poultry.
9. Grass and disease management that is organic.
10. Conservation of soil.
11. Maintenance of biological equilibrium.

3.4 Organic Fertilisers

Organic fertilisers, such as manure and compost, may help improve soil productivity and crop yields by supplementing conventional fertilisers. However, due to their lower C:N ratios, organic fertilisers applied to soils can increase N_2O (nitrous oxide) discharges, possibly contributing to global warming (Shen et al., 2018). When opposed to conventional fertiliser applications, organic fertilisers provide several advantages for farm soils and the climate, as explained below (Shen et al., 2018; Wang, 2014):

1. Increasing the organic matter content in the soils.
2. Improving soil's water-holding capability.
3. Reduction in soil degradation as organic matter increases soil porosity.

Organic fertilisers with high carbon content may stimulate microbial development, resulting in both nitrification and denitrification. Compost and other organic fertilisers have been studied extensively for their effects on carbon-nitrogen dynamics, N_2O productions and soil composition (Shen et al., 2018).

3.5 Principles of Organic Farming

Four primary principles help in organic farming (Luttikholt, 2007):

3.5.1 Principle of Health

Organic farming would benefit the health and wellbeing of the land, plants, livestock, people and the environment. It is the maintenance of personal, economic, environmental and social health. For example, it protects humans from contamination and offers them chemical-free, healthy food.

3.5.2 Principle of Fairness

The maintenance of equality and justice of the everyday world among humans and other living beings demonstrates its principle of fairness. Organic cultivation improves people's lives and aims to alleviate hunger. Natural resources must be utilised wisely and kept safe for forthcoming generations.

3.5.3 Principle of Ecological Balance

Organic agriculture can be based on biological processes. Organic cultivation practices must be compatible with natural ecosystem balances and periods.

3.5.4 *Principle of Care*

Organic farming can be done with caution and responsibility to support the needs of present and future generations and the climate. Organic agriculture, unlike industrial and traditional farming practices, does not depend on synthetic pesticides. It uses sustainable organic methods to improve soil productivity, such as improving plant nutrition by microbial activity. Second, organic farming's multiple cropping increases biodiversity, which improves sustainability and stability while still contributing to a sustainable farming environment.

3.6 Unsustainability of Conventional Farming

There are specific reasons due to which modern farming is considered unsustainable (Kingwell, 2011; Sverdrup et al., 2017):

1. Soil productivity is lost because of improper toxic pesticide usage.
2. Water supplies are contaminated by nitrate drainage after rainstorms.
3. Soil degradation because of deep ploughing and heavy rains.
4. Increased fuel needs for agriculture.
5. Animal cruelty in terms of living, feeding, breeding and slaughtering.
6. Monoculture has resulted in a loss of biodiversity.
7. Invasive creatures and hybrids take up more room than native animals and plants.

3.7 Essentials of Organic Farming

When we begin using/performing organic farming methods, we must ensure the presence of specific essential characteristics and components explained as follows:

3.7.1 *Farmyard and Other Organic Manures*

Farmyard, poultry and other manures are decomposed combinations of farm animals' dung and faeces and debris and leftovers from roughages or fodder. Cow dung, bird droppings, excess grass and other dairy wastes are used to make it. It is highly beneficial, and some of its characteristics are as follows:

1. These are nutrient-dense.
2. As manures can be combined, the plants receive a well-balanced diet.
3. Potassium and phosphorus availability is comparable to that of inorganic sources.
4. Application of manures to the soil increases its productivity.

Manure that strengthens the soil composition is used as a natural fertiliser in agriculture. It expands the soil's ability to hold more water and nutrients. It also boosts the soil's microbial production, which improves mineral availability and plant nutrition. Manures like farmyard manure (FYM) deliver all major nutrients (N, P, K, S, Ca, Mg) and micronutrients for plant development (Cu, Fe, Mn and Zn). As a result, it acts as a mixed fertiliser. Farmyard manure helps improve the physico-chemical and biological properties of the soil. The application of FYM improves the soil composition, which creates a more robust atmosphere for root growth. FYM also upsurges the capacity of the soil to hold water (Tadesse et al., 2013). In the Indian subcontinent, FYM is the most used sustainable manure. It's a composted combination of cow dung, stable bedding and the leftovers of straw and plant stalk fed to cattle. In India, rainfed (non-irrigated) dryland cultivation accounts for roughly 70% of the cultivated land (144 million ha). Dryland agroecosystems have poor crop yields due to low soil moisture and nutrient supply. Due to low soil moisture levels, chemical fertiliser usage is restricted in these agroecosystems. Low-input organic cultivation has been proposed to preserve soil moisture and increase soil productivity to realise the maximum economic capacity of these thinly spread drylands (Ghoshal & Singh, 1995).

3.7.2 Vermicompost

Vermicompost is a nutrient-dense organic fertiliser and soil conditioner that contains water-soluble nutrients. It is a mixture of decomposing vegetable or food wastes, bedding materials and vermicast created by the decomposition process of various worm species, most commonly white worms, rid wiggler worms and other earthworms. The process of vermicompost production is referred to as vermicomposting, and the practice of raising worms is referred to as vermiculture. Vermicast is the final outcome of earthworms decomposing organic matter (also known as worm humus, worm faeces, worm manure or worm castings). The castings are known to have less contaminants and a higher nutrient saturation level than organic materials prior to vermicomposting.

Key Benefits of Vermicomposting The following are the key benefits of vermicomposting:

1. Vermicomposting provides nutrient-rich castings and diverts wastes from landfills.
2. As compared to conventional composting, lesser space is needed in vermicomposting.
3. There is a reduction in the amount of strength needed.
4. Compost processing can be done more quickly.
5. Red wiggler worms consume half of their body weight in food waste every day.

Vermicompost is superior to compost because of its higher N, P and K contents and its potential to enhance soil structure and retain more water. Vermicompost is an excellent organic manure for improving plant growth and yield. Vermicomposting is a basic biotechnological composting technique in which some earthworms improve the waste conversion method and provide a healthier product. In many aspects, vermicomposting varies from composting. It is a mesophilic system that makes use of earthworms and microbes that survive between 10 and 32 degrees Celsius (not ambient temperature but temperature within the pile of moist organic material). The process is faster than composting since the waste is absorbed by the earthworm's intestine. It undergoes a significant but little-known transformation, yielding vermicasts rich in plant growth regulators, microbial activity and pest repellent properties. In a nutshell, earthworms transform waste into gold through biological alchemy (Adhikary, 2012). Vermicompost has the same recorded advantages as traditional composts, such as providing organic matter, improving moisture retention and increasing nutrient absorption and plant hormone-like action. Enhancements in the physico-chemical composition of the growth media have been attributed to the increased plant growth. However, it suggests that using vermicompost impacts plant growth that is not explicitly related to physical or chemical properties. Any growth promotion appears to be attributed to plant hormone-like behaviour associated with vermicomposting microflora and metabolites formed due to secondary metabolism (Bachman & Metzger, 2008).

3.7.3 Green Manuring

Green manuring is the process of incorporating undecomposed green plant tissue into the soil. A green manure crop aims to introduce the organic matter to the soil. Because of the incorporation, the soil's nitrogen intake is improved, and some nutrients become more readily accessible, improving the soil's efficiency. It aids in the preservation of arable soil's organic matter content (Farooqi et al., 2021). It acts as a source of energy and food for microbes that multiply quickly, not only decomposing the green manure but also releasing plant nutrients in usable forms for crop usage. The function of a green manure crop differs depending on the circumstance, but the following are some of the advantages they provide:

1. Increasing soil humus and organic matter.
2. Increasing nitrogen fixation.
3. Defending the soil's crust.
4. Preventing the process of erosion.
5. Keeping or changing the composition of the soil.
6. Access to unavailable nutrients from the lower soil profile.
7. Reducing soil vulnerability to leaching.
8. Ensuring access to readily accessible nutrients for the next generation of crops.

Green manuring is a method of soil enrichment that involves plowing under or adding certain green manure crops into the soil when it is either green or shortly after they begin to bloom. The importance of green manuring resides in the incorporation of organic matter into the soil is widely acknowledged as one of the essential components for proper soil fertility. Green manure crops are cultivated to produce green manure that has only recently become common among our farmers. According to estimates, a green manure crop that is 40–50 days old provides up to 80–100 kg N ha^{-1}. A green manure crop replaces 50–60 kg fertiliser N ha^{-1}, even if half of this nitrogen is crop utilisable. Dhanicha, sun hemp, cowpea, mung, potato, guar and berseem are possible green manuring legumes. These crops grown during the Kharif season have been recorded to contribute 8–21 tonnes of green matter and 42–95 kg of N per hectare. Similarly, during the rabi season, cowpea and berseem contribute 12–29 tonnes of green matter and 67–68 kg of N per hectare (Dubey et al., 2015; Mishra & Nayak, 2004; Sharma et al., 2013).

3.7.4 Organic Matter Application and Restoration

The three major components of soil organic matter (SOM) are small (fresh) plant residues, decomposing (active) organic matter and solid organic matter (humus). Soil organic matter serves as a nitrogen and phosphorus reservoir for crops, enhancing fertiliser exchange, preserving moisture, decreasing compaction, reducing surface crusting and rising water infiltration. SOM does not include plant nutrients on the soil surface, such as leaves, fertiliser or seed debris, which are usually sieved out of soil samples prior to examination using a wire mesh (Farooqi et al., 2018).

Plant residues with a low carbon:nitrogen ratio (high nitrogen content) decompose more rapidly than those with a high carbon:nitrogen ratio (low nitrogen content) and contribute less organic matter to the soil. Excessive tillage destroys soil aggregates and accelerates the decomposition of organic matter in the soil. Healthy soil aggregates increase the amount of usable organic matter in the soil, thus shielding it from microbial deterioration. Accelerating SOM decomposition requires steps to increase soil moisture, temperature and aeration. SOM may be degraded or increased depending on the management measures used on the areas being analysed. The following are some main steps that may help improve SOM (Umar et al., 2020):

(a) Use of cropping systems.
(b) Reducing or eliminating tillage.
(c) Reduce erosion using appropriate measures.
(d) Soil-test and fertilise properly.
(e) Use of perennial forages.
(f) Nutrient supply.
(g) Water-holding capacity.
(h) Soil aggregation.

(i) Erosion prevention.

Organic matter in the soil is diverse and heterogeneous, made up of a variety of organic materials that are preserved to differing degrees through physical isolation from microbial biomass, molecular recalcitrance and direct contact with clay surfaces and inorganic ions (Shepherd et al., 2002).

3.7.5 Crop Rotation

Crop rotation is the practice of planting multiple crops on the same plot of land in order to improve soil quality, maximise fertiliser availability and combat pest and weed pressure. Consider a farmer who has cultivated a cornfield. He could plant beans after the corn harvest is over since corn absorbs many N and beans return N to the soil. Simple rotations may consist of two or three crops, whereas complicated rotations may have a dozen or more (Behnke et al., 2018).

3.7.5.1 Principles for Crop Rotation

Crop rotation has several general rules, described as follows:

1. Plant a high N-demanding crop after a legume crop.
2. In a particular region, grow annual crops for just 1 year.
3. Do not plant one crop after another that is directly associated.
4. Use seed sequences that encourage the growth of healthy crops.
5. Implement weed-controlling seed series.
6. Use seasonal crops for more extended periods on sloping land.
7. Use a deep-rooted crop in rotation.
8. Use crops that can leave a large amount of residue in the rotation.
9. When cultivating a diverse range of crops, divide them into blocks based on plant families, crop timing, crop form (leaf vs fruit vs root), fertiliser requirements or crops with common cultural traditions.

3.7.5.2 Steps for Crop Rotation and Planning

In organic farms the following steps are adapted from crop rotation (Mohler & Johnson, 2009):

(a) Determine and prioritise the crop rotation priorities (e.g. environmental enforcement, weed management, soil quality and disease control).
(b) Create a crop mix list.
(c) Look for an overabundance of land in one family.

(d) Prepare a crop rotation plan, noting which beds or fields (or parts of fields) are at risk of affecting such crops.
(e) Find crop couplets and short sequences that are appropriate for your farm (including cover crops).

3.7.6 Mulching

Mulch is essentially a substance that is applied on top of the soil to have a protective layer. Mulches may be inorganic (plastics, bricks and stones) or organic (wood chips, grass clippings, straw and other similar materials) with a number of benefits including the following:

- Protects the soil from erosion and alleviates compaction caused by heavy rains.
- Conserves moisture and eliminates the need for regular irrigation.
- Maintains a more constant temperature in the soil.
- Prevents the proliferation of weeds.
- Maintains the cleanliness of fruits and vegetables.

Chemical mulching has been used to successfully kill weeds and minimise soil degradation in organic growing schemes by directly providing organic C nutrients to the soil. It also helps conserve soil moisture and buffer abrupt shifts in soil temperature, particularly in sandy soils where significant differences in soil temperature and soil moisture are common (Tu et al., 2006). Chemical mulches have a mixed effect on crop production. Mulching enhances plant development, production and consistency of yield. The release of nutrients from decomposing mulches (both quickly and slowly decomposing) may benefit the soil (Sinkevičienė et al., 2009). It also impacts humans in terms of cost, aesthetics and ease of service and weeding. It is the key to any garden or orchard's success, particularly during a drought (Farooqi et al., 2020a, b). In semi-arid and arid areas, it's even great for the greenhouse or orchard. It acts as an insulator, allowing the soil temperature to be cooled and moderated through hot days and cold nights. It boosts the development of beneficial microbes and aids in the prevention of diseases. Additionally, it protects soil moisture from excessive solar rays and air movement through the soil surface, resulting in decreased soil moisture loss (Ranjan et al., 2017).

3.7.7 Integrated Nutrient Management

Integrated nutrient management (INM) is a term that refers to the most environmentally friendly method of disposing of crop residues, producing high-quality compost for soil fertility maintenance and supplying plants with the optimal amount of nutrients available during the life cycle to support the yield (Selim, 2020).

The following elements are the essential components of the INM scheme (Chen et al., 2011; Wu & Ma, 2015):

1. All possible nutrient sources that can be used to develop nutrient input programmes with the goal of increasing nutrient use production and high yield performance must be carefully considered.
2. The forms and quantities of soil nutrients in the root zone, also referred to as soil balance, and their availability to meet cover crop requirements.
3. Identifying and mitigating nutrient losses, especially in intensive agriculture.
4. Taking into account all factors affecting the plant/nutrient relationship in order to achieve high yield production, which is a critical aim and major advantage of integrated nutrient management (INM), water use efficiency, grain superiority, high economic returns and sustainability.

4R's of Nutrient Management
There is a popular nutrient management of 4R technology given below:

1. Right source.
2. Right rate.
3. Right time.
4. Right place.

3.7.8 Zero Tillage

Zero tillage describes arable land that receives no tillage between harvest and sowing. It's a low-tillage method in which the grain is sown directly onto the land that hasn't been tilled since the previous crop's yield. Herbicides and adequate mulching are used to manage weeds, and the stubble is held for erosion control.

There are some advantages of zero tillage which includes:

1. Reduced soil erosion caused by wind and water (because the mulch cover of previous crops covers the soil).
2. Compaction of the soil is reduced.
3. Soils that are more fertile and robust.
4. Moisture evaporation is reduced.
5. Cost savings on diesel and labour.

Land degradation on a physical and chemical level, a deficiency in organic matter, reduced ecological activity in the soil and crop yield loss are all effects of intensive or traditional agriculture. Sustainable agriculture, on the other hand, envisions a prosperous and long-term farming system based on three basic principles: soil-free agriculture, crop rotation and a constant soil surface littered with plan debris and vegetation (Shrestha et al., 2018).

3.8 Benefits of Organic Farming

There are several benefits for organic farming, which are briefly discussed as follows:

3.8.1 Crop Productivity

Crop production is increased as organic farming is practised. To increase productivity and sustainability, existing cropping systems must be transformed to address growing environmental effects and reduced inputs. Since organic farming does not encourage pesticides and is generally thought to focus more on crop variety than its traditional equivalent, it is regarded as one type for improving the resilience of current agriculture and cereal-rich cropping systems (Bedoussac et al., 2015). Increasing crop yields by adding organic matter to the soil is a well-known procedure. According to several studies, the use of organic materials improves rice grain and straw production. Some researchers reported that the spent mushroom and rice straw compost improved rice grain yields by 20% over NPK fertiliser. The benefits of organic farming are established for developed and developing countries in terms of biodiversity conservation, environmental improvement, decreased energy use and carbon dioxide emissions, increased crop production without excessive dependence on expensive inputs and sustainable resource use (Yadav et al., 2013).

3.8.2 Soil Fertility and Biological Parameters

Biological parameters are a significant part of soil quality evaluation. These biological properties are critical when evaluating soil quality because flora and fauna in the soil significantly impact it. Soil microbial biomass and microbial interactions are essential for soil fertility to be sustained. A balanced ratio of microbial biomass and operation in the soil is needed to ensure the continuous release of nutrients to plants. Organic farming has been shown to increase microbial biomass and operation by 20–30% and 30–100%, respectively, as compared to conventional agriculture. A soil with a solid organic matter content has more microbial activity and more soil N, providing strength than a soil with a low organic matter content (which is managed inorganically). Furthermore, soil organic matter can absorb CO_2 from the atmosphere, raising the carbon content of the soil and thereby enhancing microbial biomass and respiration.

3.8.3 Sustainable Soil Management

There are several components of sustainable land management. The approach and its implementations have a fragile yet complicated framework, explaining the variety of ingredients and medications (Kwiatkowska-Malina, 2018).

3.8.4 Water Management

Sufficient moisture in the soil's root area during the growing season of the plant is the most important factor in ensuring steady plant growth in sustainable agriculture. The average rainfall is the first indicator of precipitation. In situations where rainfall is insufficient, irrigation water can be used to provide the required water. A decrease in yield is typically caused by inadequate or excessive soil moisture in the plant root region.

Water resource sustainability is a relational, physical, fiscal and ecological term. Future generations' water uses, drainage, agricultural and recreational water storage and habitat conservation programmes are also covered by sustainable water management. The following factors should be weighed to maintain its long-term viability (Chiappetta,, & K. J. L. R. o. B., 2017):

- The irrigation system should be continuously tracked.
- The pumps should be operating at full capacity, the water volume should be measured and the water distribution should be even.
- The irrigation time and volume should be determined in relation to the plant's water requirements, with the aim of ensuring the most effective water use possible.
- Irrigation should be discontinued during windy conditions and in the middle of the day; instead, it should be done at night, with drip irrigation used as required.
- The facility's load should be kept as high as possible.
- Pipes should be tested regularly, and leakage should be stopped.
- Poisoning of water supply and drainage channels should be avoided in any case.
- To avoid waterborne degradation, it is essential to ensure that water is infiltrated into the soil using agricultural principles and drainage methods.
- Water quantity and distance from water supplies should be considered when preparing output.
- Raw agricultural wastes and wastewater should not be discharged into natural surface waters.
- Measures should be taken to mitigate irrigation's harmful impact on the environment.

Drone and sensor technology may also be used to gather data for the implementation of a successful irrigation methodology (Farooqi et al., 2021):

- Soil moisture meters are used to determine the demand for water in the soil.
- Thermal photographs of soil and crop moisture material collected from drones.
- A multispectral camera can detect nitrogen deficiency.
- A variable-rate irrigation scheme should be designed based on environmental data and forecasts.
- Variable-rate implementations should be performed at the best possible time in areas of different water requirements.

3.8.5 Pest and Disease Management

Integrated pest management (IPM) is a foundational technique used in modern agriculture that utilises all available plant defence strategies. IPM involves integrating successful approaches to eliminate risks to human health and the environment by preventing the proliferation of insect species and ensuring that plant management pesticides and other methods of action are used at economically and ecologically justified levels. A well-designed integrated pest management system (IPM) consists of three critical stages for maximum effectiveness and minimum environmental effects in weed, disease and pest management (Tuğrul, 2019):

(i) Identifying rodents, viruses and weeds is the first step for farmers, followed by settling on physical, chemical, biological and regulatory enforcement choices.
(ii) After identifying invasive plants, keep an eye on reproductive rates.
(iii) As the number of invasive organisms exceeds a certain level, several safety options are enabled. The most efficient protection strategy against invasive plants is using chemicals that do the minor environmental damage with all defence strategies. Crop loss may also be reduced by crushing early or through other physical defence techniques. The presence of helpful species should be considered when choosing a defence system, and dangerous species may be battled with pest-fighting species without chemicals.

3.8.6 Cover Crops and Crop Rotation

Cover plants may be grown between the central plant rows during off-season cycles when the soil is bare. They reduce the need for herbicides while preventing soil degradation, renewing soil resources, controlling weeds and protecting soil health. It is the method of manufacturing various goods in the sector one after the other year after year. As a result, various portions of the soil are used for different crops, and pests and pathogens unique to each crop are kept at bay. Covered plants contribute significantly to agricultural productivity by protecting the land; maintaining the desired temperature, humidity or illumination; and controlling pests and weeds. The weed problem has emerged as a result of sustainable agriculture's reduced soil cultivation. Clover, vetch, trefoil, oats, wheat and sorghum are only a few examples of plants with a broad range of uses and cultivation purposes. Cereals, for example, are superior at weed management, while legumes excel at nitrogen addition to the crop plant. The most critical thing to remember when growing cover plants is to strike a compromise between the system's expense and benefits.

3.9 The Organic Food System

Organic agriculture is a mode of development that promotes vegetation, ecosystems and human health. It is based on natural processes and methods that have been modified to local environments, rather than the input of any harmful chemical. This system consists of various steps, which are described below:

3.9.1 Classification

There are three separate food system classifications, conventional, transitional and the other brands, including seasonal, renewable, pesticide-free and environmentally safe. The word "clean" refers to plants, goods, processors and other value-added intermediaries in the production-to-consumption chain that has been approved by certifying bodies (CB). The certifying bodies are fee-for-service organisations and are typically supervised by the National Food Inspection Authorities. Organic certification is a lengthy procedure that takes at least 3 years to complete if done on a farm that was already farmed using traditional techniques. This means that all chemicals have been leached from the soil and that time has been allowed for organic amendments to restore soil fertility.

Transitional organic is a regional label for farms that have made the commitment to pursue organic certification. For example, the word "transitional" refers to farms that have converted to certifiable organic practices and are in the 36-month period between the last pesticide application and the time when the soil will be declared chemical-free and the farm certified organic. Small farmers catering to local/regional clients also use labels like natural, local, environmentally sustainable and pesticide-free. Except for selling board-regulated goods such as dairy or chicken, the processing and storage of items marketed under these brands are primarily unregulated, except for governmental entities and district health units. Consequently, the knowledge on farms that are not certified organic is dispersed and incomplete.

3.9.2 Production

Organic farming is a comprehensive system aimed at the growth and fitness of agro-ecosystems such as soil, plants, cattle and humans. The primary aim of organic farming is to create profitable and environmentally friendly (Hamzaoui-Essoussi & Zahaf, 2012).

We may divide organic farmers into three divisions based on how they leverage the supply chain to bring their goods to consumers: big-, mini-, and medium-sized operations. Large farmers can be identified by organic cash crops that are exported or imported immediately after harvesting, as well as livestock and field crops that are more likely to be shipped to dealers and processors for further processing. In this case, most dairy farms will be called significant producers. Medium-sized businesses typically cater to a broader local sector (Hall & Mogyorody, 2001). Due to infrastructure constraints, some of these farmers band together to grow their goods, collaborating with complementary companies to increase their on-farm market's offerings and draw more buyers. Others also formed alliances with small regional processors and manufacturers to hit restaurants and speciality food retailers. Most medium-sized growers have on-farm markets set up as permanent storefronts, with goods offered on consignment or resold to other farmers in the region. Small organic farmers are less likely to employ delivery mediators. Farmers' markets and on-farm markets are where they work on building direct partnerships with customers. They may supply a few restaurants, speciality stores or small grocers, but these are carefully nurtured partnerships that depend on niche marketing and personal connections. Owing to the paperwork and costs involved, small farmers are more likely to abandon organic certification.

3.9.3 Distribution

In recent years, organic food has been a significant segment of the food retailing industry. Natural produce has slowly progressed from specialised markets, such as independent retail shops, to mass markets, such as massive grocery chains (Jones et al., 2001; Tutunjian, 2008). Speciality retailers (95%) accounted for most of the revenue 10 years ago, with mainstream stores accounting for the remaining 5%. The pattern has now been reversed (Monitor, 2010). Farmers' markets and other alternate delivery networks are utilised and feature a clear connection between the manufacturer and the customer (Smithers et al., 2008). Distributors in several countries are marketing their product lines under particular brand names (Rostoks, 2002; Tutunjian, 2004).

3.10 Effect of Organic Farming on Climate Change

3.10.1 Reduction of Greenhouse Gas Emission

Crop and livestock agriculture emissions have increased by more than 14% since 2001, from 4.7 billion tonnes of CO_2, equal to more than 5.3 billion tonnes today. Organic farming aids in the fight against climate change by lowering greenhouse gas emissions. The volume of N fertiliser added to farmland has a direct relationship with N_2O pollution. In the EU, N_2O emissions from controlled soils account for about 40% of the total farm emissions. This is especially significant since 1 kg of nitrous oxide has a 300-fold greater warming effect on the environment than 1 kg of CO_2.

Organic farming does not enable the use of synthetic N fertilisers while concentrating on maintaining closed nutrient cycles and minimising losses by drainage, volatilisation and pollution, resulting in lower N levels per hectare on organic farms than on traditional farms, which lead to a healthy, climate-friendly development method that provides adequate food supplies.

3.10.2 Reducing Energy Use

Synthetic fertilisers and pesticides are widely used in conventional cultivation. The production of these chemicals necessitates a considerable amount of energy. Organic cultivation, however, reduces energy usage per unit of land by 30–70% by replacing the energy used to produce conventional fertilisers and utilising internal field inputs, which reduces transportation fuel consumption as well.

3.10.3 Helping Farmers to Adapt to Climate Change

Organic farming also aids in the fight against global climate change by trapping carbon in the soil. Many organic agricultural management methods, such as minimal tillage, restoring crop residues to the surface, using cover crops and rotations and incorporating more nitrogen-fixing legumes, improve carbon return to the soil. This boosts efficiency while still promoting carbon conservation.

3.10.4 Storing Carbon in the Soil

Organic cultivation aids farmers in adapting to climate change by preventing nutrient and water depletion by high soil organic matter quality and soil cover. Soils become more resistant to hurricanes, droughts and ground erosion because of this. Farmers may develop new cropping systems which respond to climatic changes. Organic farming reduces the risk for farmers by providing healthy agroecosystems and returns and lower production costs (Farooqi et al., 2018; Farooqi et al., 2020a, b).

3.10.5 Advocating for Policy Change

Organic farming can eliminate greenhouse pollution, increase land productivity and strengthen environmental resilience. As a result, we suggest that:

1. Governments recognise organic agriculture as a viable method for reducing greenhouse gas emissions and carbon sequestration.
2. Developing world policymakers should provide policies focused on the ideals of organic agriculture.
3. Appropriate mitigation actions to assist farmers in adapting to climate change through study and extension services.

3.11 Conclusions

The increasing yield loss phenomena, soil structure and quality degradation and greenhouse gas emissions have emphasised converting the current farming methods to sustainable soil use and crop productivity. So, organic farming, which uses many techniques and tools, holds a promise in making agriculture sustainable. It helps protect people's health by providing them the safer foods and protecting the health of the environment by stopping the use of synthetic fertilisers and pesticides, which otherwise damage the environment.

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