Organic Manuring for Agronomic Crops

10

Qasim Ali, Sana Ashraf, Muhammad Kamran,
Muhammad Ijaz, Abdul Rehman, Muhammad Tahir,
and Shakeel Ahmad

Abstract

Organic farming is emerging as a popular way of growing healthy, safe, and nutritious food worldwide in a long-term sustainable way that cut the indiscriminate use of agrochemicals being used globally on the cost of environmental health and safety. Nevertheless, the growing population of the world requires increased food production for that use of chemical fertilizers become inevitable. However, there might be opportunities in some crops where organic fertilizers can be encouraged to get enough food production. Keeping in view the importance of organic farming, this chapter covers the current scenario of organic farming in Pakistan and the world and its importance and effects on quality of foods and soil sustainability. Different types of amendments that can be used under organic farming system are examined and compared. Shifting toward the organic farming system is encouraged by describing its benefits with reference to plant, soil, and human health. As agronomic crops are too important in providing raw materials for food, clothes, and shelter, impact of organic farming system on quality and quantity of agronomic crops is addressed in the chapter.

Q. Ali · M. Ijaz (✉) · A. Rehman
College of Agriculture, Bahauddin Zakariya University, Layyah, Pakistan
e-mail: shakeelahmad@bzu.edu.pk

S. Ashraf
Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, Pakistan

M. Kamran
Department of Agronomy, University College of Agriculture, University of Sargodha, Sargodha, Pakistan

M. Tahir
Departments of Environmental Sciences, COMSATS Vehari Campus, Vehari, Pakistan

S. Ahmad
Department of Agronomy, Bahauddin Zakariya University, Multan, Pakistan

M. Hasanuzzaman (ed.), *Agronomic Crops*,
https://doi.org/10.1007/978-981-32-9783-8_10

Keywords
Organic manuring · Agronomic crops · Farm yard manure · Compost · Organic agriculture · Carbon sequestration

Abbreviations

CEC	Cation exchange capacity
DAS	Days after sowing
FAI	Fertilizer Association of India
FYM	Farm yard manure
GMOs	Genetically modified organisms
INM	Integrated nutrient management
Mha	Million hectare
N	Nitrogen
NAAS	National Academy of Agricultural Sciences
OARDF	Organic Agriculture and Rural Development Foundation
PGS	Participatory Guarantee Systems
USA	United States of America
WTO	World Trade Organization

10.1 Introduction

Organic agriculture is the integrated use of numerous approaches for sustainable agricultural production and development which is being adopted worldwide as it is economically viable, ecologically safe, and socially acceptable. It is the complete production management system which is widely accepted and stresses upon the adoption of all the approaches based on the use of agronomic, mechanical, physical, and biological methods in preference to off-farm inputs. Further, it opposes and discourages the use of chemical and synthetic materials which are unsafe for the environment and human health. Moreover, this system gives the central importance to soil with the basic aim to optimize the productivity of crops and health of ecological communities of humans, animals, plants, and soil. As population is increasing rapidly and requires more and more food production, food production globally is intensified by the indiscriminate use of agrochemicals (e.g., pesticides and fertilizers) to meet the increasing food demand of the multiplying population. Indiscriminate usage of agrochemicals like pesticides creates several problems like pest resistance, resurgence of pests, contamination of food, and social and economic problems. Understanding the realities, organic farming is getting popularity, and a number of countries are trying to expand organic farming system because of its importance irrespective of their stage of development. As a result, farming system model and practices are now shifting from indefinite enlarged production and yield to product quality, system's sustainability, and eco-friendly production techniques. The traditional agriculture system merely concerns with increased production to meet the rising food demand of growing population and pay less attention to consistent and sustainable utilization of indigenous resources both natural and human. Consequently, practice of flimsy techniques and intensified application of agrochemicals are resulting in overall decreased production to the destruction of soil and depletion of soil fertility. Moreover, agricultural lands are continuously shrinking in area, water availability is declining, and whole agricultural production system is leading toward unpredictability and pollution. Concurrently, these conventional chemical-based practices are disturbing and upsetting the natural resources and local knowledge system making the agriculture system inadequate and unsustainable.

In several ways, the organic farming system promotes and boosts up healthy and safe ecosystem by regulating biological life and biodiversity. Organic agriculture is a sustainable and reliable structure which mainly focused tomorrow's ecology rather than today's economy. Over the last four decades, dependency upon artificial substances like fertilizer, pesticides, growth hormones, modern farming system, etc. has been increasing manifold. Due to which, soil health, human health imbalance in natural habitat, and other hazards like erosion problems and contamination of drinking and irrigation water are more common. Ultimately it causes higher cost of cultivation with poor-quality food. Therefore, it is a dire need of the day to shift from the conventional artificial product-dependent farming system to a sustainable organic farming system. Keeping this in view, this chapter reviews the worldwide current scenario of organic food production with special context to Pakistan (Sect. 10.2); Sect. 10.3 elaborates its importance for quality of food and human health. Section 10.4 discusses the effects of organic forming on soil fertility, soil biota, soil structure, and plants' root growth and health. Further, carbon sequestration and sustainable soil productivity was also discussed in this section. In Sect. 10.5, different sources and types of organic amendments are elaborated. Different types of organic amendments and their importance is compared with special reference to sustainable food production. Section 10.6 discusses the organic food production system and its impact on soil characteristics (physical, chemical, and biological). Further, how organic amendments can suppress plant diseases are also described in this section. Section 10.7 of this chapter describes the influences of organic farming on improved crop yield and quality and its attributes, and the last section addresses the different challenges and barriers for adopting the organic farming system in a sustainable way.

10.2 World Status of Organic Farming

Organic food demand is increasing rapidly not only in developing but also in developed countries, but adaptation of organic farming is very slow even in the developed countries like the USA (0.2%) and in many European countries (6–10%), which is

Table 10.1 Percentage of area under organic farming in the total cultivated area of different countries of the world

Nations	Organic farming area (%)
USA	0.23
UK	4.22
Germany	4.10
Argentina	1.70
Austria	8.40
Australia	2.20
Japan	0.10
Switzerland	7.04
South Africa	1.05
Italy	3.70
India	0.03
Pakistan	0.08
Sri Lanka	0.05

Source: FiBL-IFOAM Survey 2012

1% of the world's cropped area. According to estimation, the concept of organic agriculture is emerging at a high rate. Organic food demand is also increasing rapidly, and this is the reason that almost 170 nations are growing organic food on commercial basis. Asia (36%) is the largest organic food producer followed by Africa (29%) and Europe (17%). In Asia, organic agriculture is flourishing day by day, and most of the developing countries (65%) are focusing to grow organically. Latin America, Australia, Argentina, Brazil, Europe, and Oceania produced organic food on a larger scale. According to a survey in year 2007, globally 32.3 Mha of organic food was produced by 1.2 m growers/farmers; even small landholders also participated in this figure. About 0.4 Mha of agricultural land is certified organic aquaculture. According to year 2006 and 2008 comparison, more than 1.5 Mha of land area was grown organically in year 2008.

According to a report in Latin America, more than 1.4 Mha (28%) of agricultural land is under organic farming, and in Brazil 0.9Mha of area is under conversion, but data is unavailable. So an increase in organic farming has been observed in Europe and Africa (+4%, 0.33 Mha and +27%, 0.18 Mha, respectively) (Willer and Klicher 2009). Austria is the leading country which produces organic food by adopting organic agriculture (8.4%), followed by Switzerland (7.04%), the UK (4.22%), and Germany (4.10%). While only minor area about 0.03% is under organic farming in India, which is very less than the scope (Table 10.1).

Internationally, organic farming system increased 6 Mha in 2013 than in 2012, as 5 Mha rangeland came into organic cultivation just in Australia. Globally, $25 billion were marketed by organic food in 2002 and $12 billion in the USA. In 2013, earing from organic product was reached to peak (US $72 billion), indicating almost five times more increased since 1999. Cuba is a more prominent and leading organic food producer by using low inputs and indigenous renewable resources. Organic agriculture is flourishing rapidly and providing organic food to the nations with eco-friendly techniques on sustainable basis. Though contribution of organic farming is very less, consumer of organic food is increasing day by day predominantly in the USA and Europe (Willer and Lernoud 2015).

Currently, organic agriculture has set certain standards and protocol for health and safe food production. Laws (almost more than 80 national laws) have been developed, and 16 nations are in the development of drafting legislation. Furthermore, alternative organic food certification protocol has been devised by 38 countries, focusing quality assurance Participatory Guarantee Systems (PGS) on local level, while 17 countries are under development under this system. Approximately, in US and European markets, consumption of organic food is about 80%; however, 75% of organic food production is not produced in these chief marketplaces.

10.3 Organic Farming in Pakistan

World Trade Organization set up food standards and followed strict policy to produce healthy and safe food. Pakistan also signed WTO memo and categorically present Euro Good Agricultural Practice (Euro GAP) to the farmers by upgrading its farming standards according to the international standards to enhance their export.

Pakistan is among those countries, which Allah has blessed with diverse and ideal growing conditions not only for crops but also for animal husbandry too. Pakistan is an excellent place for growing of organic food, and there is a huge scope for organic farming. A vast area is highly fertile and productive which can easily be brought under organic agriculture. Surveys should be made to initiate organic farming, and potential of agriculture land should be identified to convert it from unfertile to fertile and productive land. Farmers and local enterprisers should be educated about the huge income returns by growing organic foods.

Pakistan Organic Farms (POF) is one of the leading rice exporters in Pakistan certified by Control Union Certifications, Zwolle, the Netherlands, for organic production of organic basmati rice, sesame seeds, cotton, and wheat. This organization is also affiliated to “Organic Agriculture and Rural Development Foundation (OARDF),” a nongovernmental organization working for organic agriculture and ruvral development. This foundation is introducing latest advanced techniques for growing of organic foods in Pakistan.

The Ministry of Food, Agriculture and Livestock made an agreement with an American company to import organic cotton (50,000 bales) from Pakistan. The meeting was chaired by the Federal Secretary of Agriculture. During this meeting experts recognized that area of Baluchistan has a great potential for growing of organic crops especially cotton. Because the agriculture area of Baluchistan is free from pest pressure and uses synthetic chemicals minorly if compared with the other parts of Pakistan, its production of cotton during 1998–1999 was around 28,000 bales.

It was concluded that the quality of chemically grown cotton in province Baluchistan is better than the rest of the provinces. So, quality of the cotton will further improve by introducing organic farming.

During 1997–1998, supporting price of seed cotton by using chemical was around Rs. 620 per 40 kg. Although organically produced cotton might have less yield, there is a need to introduce premium price for farmers to motivate them to grow more and more organic crops. According to estimate, prices of chemically grown seed cotton (50,000 bales) would be around Rs. 132 million, while it was expected that organic cotton would be two to three times more to motivate farmers.

10.4 Importance of Organic Farming

Organic farming may be defined as production of safe and healthy food to compensate bad impacts of the green revolution on air, topography, soil, water, and humans globally. This kind of cultivation is considered to be eco-friendly due to the elimination of all kinds of synthetic inputs for crop production. For organic agriculture, specific areas are defined and all kinds of inorganic substances like fertilizers, pesticides, veterinary drugs, hormones, additives, preservatives, etc. and genetically modified seeds (GM seeds) and breeds forbidden in organic crop production system. All these substances are replaced by site-specific farm management system to enhance soil fertility and soil productivity and to prevent pests by applying organic and on-farm substances. Inorganic fertilizers are prohibited, and the success of system is based on good soil management, and progressively enhanced soil organic matter and microorganism community ultimately build up soil carbon (Hodges 1991).

Organic agriculture can be adopted and developed to fulfill the world's food demand on sustainable basis. Organic farming is not only providing and ensuring food safety but also showing a significant part in land and soil degradation managing; solving atmospheric issues; minimizing poverty, hunger, and health issues; and biodiversity. Organic agriculture also provides employment to the rural people by diversifying economy by gaining foreign exchange. Organic farming can be extra gainful (22–35%) and have more 20–24% benefit/cost ratios as compared with conventional agriculture; actual payments are applied. Economically, organic agriculture might be chosen for lesser ecological prices and boosted environment facilities from the acceptance of respectable agricultural practices (Crowder and Reganold 2015).

Worldwide, farmers, researchers, and scientists are continuously adopting organic farming. In organic farming on farm and local resources like FYM, crop management and indigenous seed protection measures are the major elements for efficient use.

Organic farming follows a route to promote self-regulation and natural resistance in plants and animals by making them strong against adverse environmental conditions. In this farming system, appropriate new and traditional technologies used in a wise manner named as sustainable farming. The main principles of organic farming are as follows (Manivannan et al. 2015; Yuda et al. 2016):

1. To use local resources as much as possible within a closed system.
2. To use soil wisely so the soil fertility remains intact for a long time.
3. To keep the atmosphere safe from any type of pollution due to agricultural methods.
4. To grow food with adequate quantity and high dietary value.
5. To diminish the practice of fossil energy in agriculture.
6. To provide suitable livestock living conditions to confirm their physical desires.
7. To provide all the benefits and suitable conditions for agriculture producers so that they may explore their maximum potential for the people.

Organic farming provides the following services.

10.4.1 Greater, Deeper Root System

A few aspects of organic farming surge the level of roots in the soil and also result in the roots extending more deeply into the soil, where less mineralization takes place. This may be an important contributor to the soil carbon levels. Roots are also key contributors of the carbon in the subsoil, where the soil carbon is much more stable. There is a large increase in age of carbon with soil depth. Therefore, any increase in the subsoil carbon store is very significant for long-term carbon sequestration. Organic farming provides 72% more root biomass carbon per hectare than nonorganic farming (Soussana 2008).

10.4.2 Higher Level of Living Soil Organisms

Organic farming promotes the soil life. It is revealed that organic farming supports a greater abundance of organisms in cultivated soils, including more earthworms, mycorrhizal fungi, and bacteria. Evidence is growing that this may be one of the main reasons for higher soil carbon levels of organic farming. The greater level of soil microorganisms does not itself account for the higher soil carbon levels of organic farming. Soil microbes commonly constitute only 1–2% of the soil carbon store in arable land. But the activities of soil organisms are highly influential in the stabilization of soil carbon input and thus the accumulation of soil carbon. The polysaccharide gums produced by microorganisms and the network of hyphae of fungal mycorrhizae bind the soil's mineral particles into aggregates which then encapsulate and protect humus against degradation. Larger populations of earthworms might also help distribute more soil carbon to the deeper layers where the soil carbon is longer-lasting. Arbuscular mycorrhizal fungi have been shown to enhance soil aggregation, and recently a major portion of soil carbon store has been recognized which is produced by hyphae of mycorrhizal fungi in the form of glycoproteins. Higher levels of mycorrhizal fungi are not just a by-product of organic practices but are fundamental to the organic farming system. The agronomic crops supply fungi with sugars, and in response crops receive minerals and water through hyphae of fungi, which acts as crop's own root system.

10.4.3 Nonuse of Inorganic N Fertilizer

The replacement of inorganic N fertilizers by biological N fertilization methods in organic farming avoids the negative knock-on effects of relying on inorganic fertilizers and also avoids any more direct effects. Several long-term trials around the world have shown that inorganic N fertilizers do not raise soil carbon levels and the levels remain low in the absence of positive soil management practices (Heidmann et al. 2002).

10.4.4 Better Soil Structure and Winter Vegetation Cover

Soils with higher organic matter contents have particles in more aggregated form that gives it a healthy crumb structure which is less susceptible to erosion. This is because, in such a condition, the soil particles are more stable and the soil surface is more open, enabling water to percolate instead of passing over the surface and causing erosion. In organic farming, some cereals are undersown with legumes which then remain after the cereals are harvested and act as a winter cover crop. Winter cover crops guard the soil from destruction by avoiding the development of rills and small gullies and by providing food for earthworms, fungi, and other soil microorganisms whose by-products increase soil particle aggregation (Mader et al. 2002).

10.4.5 Carbon Sequestration Potential of Organic Farming

In recent years, increasing amounts of atmospheric CO_2 and methane (CH_4) emission have raised an interest to study the soil dynamics of organic matter and carbon sequestration potential and understand capacity of soil as source or sink role on global basis (Van-Camp et al. 2004). Organic substances like compost and other carbon containing materials mixed into the soil, organic carbon decomposition starts by producing CO_2 and another part of compiled in the soil. Carbon sequestration term is used first time by Lal (2007) which describes transformation of atmospheric CO_2 into soil C pool through:

(i) To form humus by adding crop residues and other waste materials in the soil.
(ii) In arid and semiarid areas, carbonate leaching or secondary carbonate formation may take place.
(iii) Carbon attached with organo-mineral complexes formation, and it is less affected by the microbes.
(iv) Organic carbon is translocated in the subsoil and by plowing, and agronomic practices can transfer it away from the root zone, diminishing the hazards of being detached by erosion.

CO_2 sequestration in cultivated soils promotes sustainable cropping methods through organic farming by reducing soil disturbance and optimizing water-use efficiency. However, C dynamics is also influenced by incorporation of organic material in the soil. Carbon sequestration is good to enhance soil organic carbon reservoir and helpful to reduce the global warming. Triberti et al. (2008) conducted a series of experiments about 29 years in which comparison was made among manure and slurry of cattle and residues of crops mixed with synthetic fertilizer and found that the quickest carbon sequestration (0.26 t ha^{-1} $year^{-1}$) was built up through cattle manure which contains 33.1% of organic C and 27 kg C ha^{-1} is compiled in the 0–40 cm soil layer. This rise is linked to maximum sequestration efficiency equal to 8.1% incorporated C, because of its minimum degradability, than the cases of cattle slurry and cereal crop residues with 3.8% and 3.7% C addition, respectively. Carbon residues of incorporated manure and compost remained up to 25% and 36%, respectively, showing higher sequestration with composted as compared to non-composted manure. It has been reported by Sodhi et al. (2009) that application of rice straw compost for 10 years with or without the combination of inorganic fertilizers resulted in carbon sequestration in the form of macroaggregates.

10.5 Sources and Types of Organic Amendments

Soil quality and fertility may be improved by adding organic substances as history told that Greeks and Romans used to do organic amendments in the soil. Animal manure and human sewage were the most common organic materials applied to the soil during cultivation. They also knew the advantage of growing wheat after legume crops. Various organic substances like farm yard manures, crop residues, sea shell thrashes, etc. were used to enhance crop growth and development. These days, compost and animal dung are the most common organic amendments which are being used for the betterment of soil. Five categories have been made for essential organic materials (Goss et al. 2013).

Organic matter amendments are made in the soil to enhance the nutrient supply to the soil. Most of the nutrients like K in the organic manures are water soluble and more available to crop. Manures from the animal sources like FYM and slurry contain 60–80% inorganic phosphate as compared to the total P content in the manure and act as same as P from the inorganic sources like phosphatic fertilizers. With the usage of nitrogenous fertilizers, production of food is doubled since the 1950s, and ultimate source of N for soil and plant was organic manures. However, nitrogen mineralization is proceeded in spring season but often higher rate of mineralization in autumn when crops needed a small amount of it and there is a lot of chances of its loss in the form of nitrate.

Mineralization boosts up due to favorable soil and atmospheric conditions by increasing microbial activity in the soil and provides energy source from incorporated crop residues. Properties of different manures are shown in Table 10.2.

Organic manures are classified mainly into two types as shown in Fig. 10.1.

Table 10.2 Properties of some manures

Manure	Physical properties			Nutrient content
	Color	Solubility	State	
Cow dung	Blackish	Water soluble	Solid	% N = 0.5–1.5% P_2O_5 = 0.4–0.8% K_2O = 0.5–1.9
Compost	Blackish	Water soluble	Solid	% N = 0.4–0.8% P_2O_5 = 0.3–0.6% K_2O = 0.7–1.0
Farm yard manure	Light green or blackish	Water soluble	Solid	% N = 0.5–1.5% P_2O_5 = 0.4–0.8% K_2O = 0.5–1.9
Mustard oil cake	Brownish	Water soluble	Solid	% N = 5.1–5.2% P_2O_5 = 1.8–1.9% K_2O = 1.1–1.3
Sesame oil cake	Blackish	Water soluble	Solid	% N = 6.2–6.3% P_2O_5 = 2.0–2.1% K_2O = 1.2–1.3

Source: Knott's handbook for vegetable growers (1997)

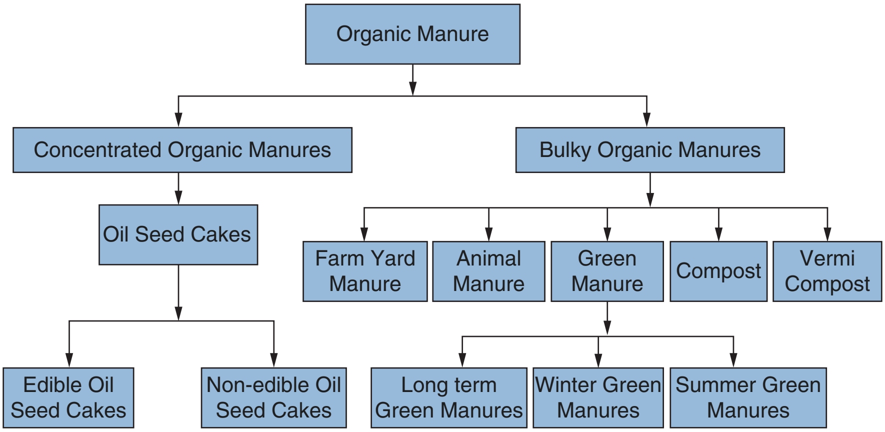

Fig. 10.1 Classification of organic manure

10.5.1 Bulky Organic Manures

Bulky organic manure includes FYM, BYM, green manure, compost, and vermin compost having less nutrients in comparison to concentrated organic manure. These manures have the following benefits:

1. They provide growth nutrients for plants.
2. They enhance soil physical characteristics.
3. They enhance the accessibility of growth substances for plants.
4. CO_2 liberated during decay functions as a CO_2 enricher.
5. Microbial activity enhanced due to regulation of plant parasitic nematodes and fungi in the soil.

Table 10.3 Nutritional status of FYM (%)

Nutrients	(%)
N	0.50
P	0.25
P	0.40
Ca	0.08
S	0.02
Zi	0.0040
Cu	0.0003
Mn	0.0070
Fe	0.45
H2O	76

Source: FAI (2012)

10.5.1.1 Farm Yard Manure (FYM)

Farm yard manure (FYM) is the most significant reservoir of growth substances for plants and refers to the finely decomposed excreta of farm animals including litter and plant residues or remaining or wastage of fodder. Uncovered storage of farm yard manure for a long time causes loss of nitrogen in the form of ammonia. The dung must be stored in 1.0-meter-deep pits, and surface is sealed with mud slurry to avoid and overcome such kinds of losses. Microorganisms play a vital role in decomposition, and manure is ready after 4–5 months. The chemical constituents present in FYM are given in Table 10.3.

10.5.1.2 Animal Manure

Animal manure is composed of feces, urine, and animal bedding stacked and turned up to finely decomposed end product. It is obtained from beef, dairy, pork, and poultry farms and its constitution based on its source, the time when urine and feces are excreted and mixed, and the storage time before being added to soil. Manure provides essential nutrients and organic matter to crops thus enhancing soil fertility. Cow dung is an excellent source of nitrogen and phosphorus (Boller and Hani 2004; Goss et al. 2013). The sheep and goats manure hold more nutrients than FYM and compost. It is employed to the agricultural farms by two different methods. The droppings of sheep or goats are kept in the pits till decomposition, and then it is used in the fields. This method results in wastage of nutrients from urine. The other process is sheep penning in which sheep and goats are kept for a night in the agricultural farms. In this way, urine as well as fecal stuff is mixed in the soil directly to workable depth through mechanical means. Application of animal manure will add important micro- and macronutrients to the soil that will be slowly released over time and construct good soil structure and texture and enhance the soil aeration as well as water retention potentials. Animal manures vary from each other based on source, age, storing method (piled, spread, turned over or not), and the animal bedding stuff that may be merged in. The general knowledge about nutrient contents of different animal manures is given (Table 10.4) which describes the approximate

Table 10.4 Animal manure type and approximate NPK percentage

Manure type	Nitrogen (N %)	Phosphorus (P %)	Potassium (K %)
Chicken	1.1	0.8	0.5
Cow	0.6	0.2	0.5
Duck	0.6	1.4	0.5
Horse	0.7	0.3	0.6
Pig	0.5	0.3	0.5
Rabbit	2.4	1.4	0.6
Sheep	0.7	0.3	0.9
Steer	0.7	0.3	0.4
Swine	3.0	0.4	0.5

Source: FAI (2012)

Table 10.5 Plants used as green manure

English name	Botanical name
Sunn hemp	*Crotalaria juncea*
Lentil	*Lens esculenta*
Egyptian clover	*Trifolium alexandrinum*
Sesbania	*Sesbania aculeata*
Cluster bean	*Cyamopsis tetragonoloba*
Cowpea	*Vigna sinensis*
Horse gram	*Macrotyloma uniflorum*
Senj	*Melilotus parviflora*

Source: FAI (2012)

levels of total nitrogen, phosphate, and potassium. FYM is basically excreta of farm animals mixed with a bit of plant residues like husk, leaves, or hay, while animal manures include animal waste (urine and dung) mixed along with a bit of soil.

10.5.1.3 Green Manures

Green manures also called as fertility-building crops can be considered as crops grown for the interest of soil. Green manures include different plants grown to feed the soil. Green manuring is a developing method to improve the soil productivity (Haynes 2004). They are low cost than chemical fertilizers and can be applied with animal manures. Application of green manure for crop production may improve economic viability, while decreasing the environmental impacts of agriculture (Cherr et al. 2006). The plants commonly used as green manure are given in Table 10.5.

Green manure crops are mostly cultivated into the soil at growing plant stage, before they flower. They are developed due to their green leafy material that contains high level of nutrients and preserves the soil. The plants are kept buried for about 1–2 months for total decomposition. The soil is then tilled, and then the next food crop is sown. By altering the green manure crop with food crop, both the nitrogen and organic matter of the soil are sustained. Green manuring is the method to

Table 10.6 Nutrient content of green manure crops and green leaf manures

	Nutrient content (% on dry weight basis)		
Plant	N	P	K
Green manure crops			
Sesbania aculeata	3.3	0.7	1.3
Crotalaria juncea	2.6	0.6	2.0
Sesbania speciosa	2.7	0.5	2.2
Tephrosia purpurea	2.4	0.3	0.8
Phaseolus trilobus	2.1	0.5	–
Green leaf manures			
Pongamia glabra	3.2	0.3	1.3
Gliricidia maculata	2.9	0.5	2.8
Azadirachta indica	2.8	0.3	0.4
Calotropis gigantea	2.1	0.7	3.6

Source: FAI (2012)

decompose plant materials into the soil for promoting the soil health by increasing organic matter and nitrogen, mainly if it is a legume crop that has potential to fix nitrogen from the air by its root nodule bacteria (Fageria 2007). The nutrient contents of green manure crops and green leaf manure are shown in Table 10.6.

The ideal green manures should have the following characteristics:

1. Have a fast growth rate.
2. Have the potential to tolerate unfavorable climatic conditions, pests, and diseases.
3. Have sufficient *Rhizobium* nodulation capability and must be a potent nitrogen fixer.
4. Should accumulate adequate fixed N in 4–6 weeks and be easy to integrate and rapidly decomposable.
5. Should produce abundant and succulent tops.

10.5.1.3.1 Process and Classification of Green Manure Crops

There are two kinds of procedures to produce green manure.

(i) **In situ green manuring crops**

In this method, undecomposed green manure crop is added into the soil of the similar agricultural farm where the crop was cultivated (e.g., sunn hemp, *Sesbania*).

(ii) **Ex situ green leaf manuring crops**

This process includes converting green leaves and tender green twigs accumulated from different sources into fine organic material. The most common beneficial plant species used for this process include sunn hemp and *Sesbania*.

Green manures are classified into the following three types:

(i) **Long-term green manures**

Leys, generally grown for 2–3 years, are essential for most of organic arable rotations. When animals are present on the farm, then leys will be grazed or cut for silage, but in stockless setup, they are cut monthly in the summer season, and the mowings are kept on the top layer as mulch. Such leys may be pure clover (when nitrogen fixation is important) or a grass/clover mixture (when organic matter buildup is also important).

(ii) **Winter green manures**

Winter green manures are normally cultivated in the autumn and integrated in the subsequent spring. They can be used as fertility-building crop in a rotation. They may be legumes (e.g., vetch), but they are mainly used (even in traditional agriculture) to reduce the nitrogen leaching; when employed for this reason, they are termed as winter cover crops.

(iii) **Summer green manures**

Summer green manures are typically legumes cultivated to enhance nitrogen in mid rotation. They can be cultivated for the full season (April to September) or for a short duration between two cash crops. These short-term manures can include nonlegumes like mustard and phacelia.

10.5.1.3.2 Objectives, Advantages, and Disadvantages of Green Manures

Green manure crops can be grown separately or in combination with crops. Generally, green manure crops are considered for the following purposes:

1. To provide soil cover with no tillage, thus minimizing water evaporation and soil temperature and improving water infiltration.
2. To save the soil from erosion.
3. To minimize weed invasion.
4. To enhance biomass in the soil (for accumulation of soil organic matter and addition of nutrients).
5. To develop soil structure.
6. To improve biological soil properties.
7. To diminish pest and disease invasion.

By performing the abovementioned functions, green manure/cover crops provide the subsequent advantages:

1. **Maintenance and/or accumulation of organic matter**

The main role of green manures is the inclusion of organic matter to the soil. Organic matter is the most important for soil health in cultivated areas as it conducts various physical, chemical, and biological activities as organic matter is the reservoir for essential plant growth substances. Once introduced, the green manure supplies abundant fresh organic matter, and there are several examples where application of green manures rises soil organic matter as compared to experiments where only chemical fertilizers are used (e.g., Shepherd et al. 2002). Crop residues in traditional agricultural practices are not sufficient to counterbalance the loss of organic matter, as a result of high mineralization in tropical and subtropical climates. In agricultural system, the cost-effective way to sustain or increase the soil organic matter is the application of green manure crops that have a high capacity for biomass production. The different plant species provide different levels of organic carbon.

2. **Soil structural improvement**

Green manures can enhance the soil structure by different mechanisms. The widespread root network of some plants like rye grass trapped the soil particles, helps to stabilize aggregates, and increases pore size and hence improves the seed-bed structure. Some species with deep taproots support to break up the compressed soil. Soil consists of different size units that can be detached by rain washing from the soil, causing impenetrable layers or pans (Breland 1995). By covering the exposed soil surface, it can be protected from heavy rain.

3. **Minimizing nitrate leaching**

If soil is left bare overwinter, then large levels of nitrate can be lost from soil, because nitrate is not firmly bound to soil particles. Leaching also reduces the nitrate that is a serious problem for organic farmers as it is very difficult for them to substitute the lost nitrogen.

The best way to prevent the nitrate leaching is to establish a dynamically growing crop during the winter season. Winter green manures can eliminate excess nitrate from the soil during the autumn. Green manures differ in their potential to minimize the leaching. Rye grass is mostly effective due to its huge leafy growth during cold weather (MAFF 1998).

4. **Loosens the soil**

Deep rooting green manures can be beneficial to loose and ventilate the soil up to greater depths; this progresses the drainage and increases the organic matter that advances the environment conducive for survival, multiplication, and functioning of valuable microorganisms.

5. **Improves the fertility of soil by adding nitrogen**

Legume family plants capture N from the air and with the help of *Rhizobia* species converts it into a form that plants can use. These plants have the potential to add large concentrations of nitrogen into the soil through biological fixation by *Rhizobium* bacteria on their roots. This nitrogen is beneficial for succeeding crops.

6. **Locks up soil fertility**

Readily available essential nutrients are washed out from bare soil in winter season during the time period of heavy rain. Green manuring crops when used as cover crop provide all the essential growth nutrients to the soil reservoir. These essential growth substances are being stored in the plant cell and released when crops die back, cut, or dug into the soil.

7. **Rests soil**

Soil that has been intensely used for agriculture requires time to improve its structure and fertility. Cultivating green manure is an effective way to protect the soil during the recovery period with all the advantages given above. Clover is a principally good crop for resting soil as it fixes the N.

8. **Pest, disease, and weed control effects**

The green manures can be helpful to control pests, weeds, and diseases. This depends on the kind of green manure employed and the succeeding crops cultivated. They may function as a habitat for predatory insects to decrease the pest pressure, but they can also develop the pests like wireworms or slugs in succeeding crops. Hence careful attention is required for cropping sequences. Green manures have a suppressive effect on diseases but some green manures like *Brassica* green manures in horticultural rotations can favor the diseases. Weed suppression can be one of the crucial advantages of green manures. However, poor control of weeds in green manure can cause harmful effects because green manure itself can become a weed for the following crops.

Green manures can also have the following disadvantages:

1. Costs of seed and extra cultivations.
2. Lost prospects for cash cropping.
3. More work at busy times of the year.
4. Intensified pest and disease problems (due to the "green bridge" effect).
5. Possibility for the green manures to become weeds.

10.5.1.4 Compost

Compost is formulated from waste vegetables and other refuse combined with cow dung, urine, town waste, and night soil. Night soil is human excreta enriched with growth substances more than FYM and compost. Night soil consists of 5.5% N, 4.0% P_2O_5, and 2.0% K_2O. Compost is applied by similar mechanism as by FYM, and its application is beneficial for different types of soils and crops. The application of compost provides both agricultural and waste management benefits. Compost is rich in nutrients and can also be used for garden, landscaping, and horticulture purposes (Perez-Piqueres et al. 2006).

Table 10.7 Typical nutrients of finished compost

Nutrient	Dry weight
Nitrogen (N)	<1% up to 4.5%
Potassium (K_2O)	0.5–1%
Phosphorus (P_2O_5)	0.8–1%
Calcium (Ca)	2–3%
Magnesium (Mg)	2–3%

Source: B.C. Agriculture Composting Handbook (1998)

The procedure of formulating the compost is called as composting. It is mainly a biological method in which both aerobic and anaerobic microbes involve in breakdown of organic substances and lower the C:N ratio of the refuse. The compost becomes ready in 3–4 months without any further attention. Composting is a cost-effective and useful way to process the animal manure for land utilization because in this method the pathogens and weed seeds are devastated and the heterogeneous solid organic material is converted into stable humic material by the action of microbes. Moreover, nitrogen level of original waste is minimized during composting process, and nitrogen is converted into a stable form (N_2) (Guo et al. 2012). Level of nutrients in finished compost will differ on the basis of type of manure, plant residue, or biosolids used. Nutrient concentration of finished compost is given in Table 10.7.

10.5.1.4.1 Types and Benefits of Compost

Composts are of the following two kinds with different composition.

(i) **Rural/village compost**

This compost is prepared from farm wastes such as straws, crop stubbles, crop residues, weeds, waste fodder, urine-soaked earth, litter from cowshed, and hedge clippings. This kind of compost comprises 0.4–0.8% N, 0.3–0.6% P_2O_5, and 0.7–1.0% K_2O.

(ii) **Urban compost or town compost**

This form of compost is formulated from town waste and night soil and contains 1.0–2.0% N, 1.0% P_2O_5, and 1.5% K_2O.

Numerous benefits obtained from the application of compost as fertilizer include (Donn et al. 2014; Scotti et al. 2015):

1. Rise in organic C and microbial activity of soil as compost has potential to stimulate the soil microbial population by inhibiting soilborne pathogen diseases like *Pythium*, *Phytophthora*, and *Fusarium* spp.
2. A huge level of plant nutrients such as N, P, K, and Mg addition.
3. The intensification of soil porosity with resultant upsurge in available water for plants.

4. Rise in cation exchange capacity (CEC).
5. Compost reduced the mineralization rates that minimize the nitrate leaching by slowing the transformation of organic N to mobile nitrate.

10.5.1.5 Vermicompost

Vermicompost (biofertilizer) is an organic manure formulated by earthworms and microorganisms as they feed on organic waste materials. The compost thus formed is mostly worm excreta and finely ground soil. Organic materials from different sources can be fed on by worms so that the wastes are converted into decomposed end product. The biologically degradable nontoxic organic matter is employed in vermin-composting process. Normally used composting feedstocks are animal dung, agricultural waste, forestry waste, and nontoxic industrial waste of organic nature. Worm casting (excreta) in the vermin compost contains nutrients that are 97% utilizable by plants. Apart from supplying plant nutrients, worms also upturn the soil and make the soil lighter. Vermicompost has been used for flowering plants for a long time. Earthworm community has hormonelike effect, stimulating the development and precociousness of plants. Vermicomposted larval litter meaningfully enhanced the length and weight of shoot and root, shoot-root ratio, and N, P, and K uptake (Garhwal et al. 2007). Vermiculture technology is being implemented for low-cost treatment of nontoxic wastes from different sources. The end product of vermiculture technology that is vermicompost is high in quality nutrients and is being progressively implemented for sustainable organic farming.

Advantages of Vermicompost

1. Earthworms present in organic matter containing soils function as natural bioreactors, stimulate the advantageous soil microbial population, suppress soil pathogens, and transform organic matter into precious product like biofertilizers, growth hormones, and tenacious worm biomass.
2. Earthworms present in the soil are involved in the modification of physical, chemical, and biological characteristics of the soil and stimulate the nutrient cycling by ingestion of soil and humus and transforming it into nutrient-enriched cast.
3. The early accessibility of different nutrients like P, Ca, Na, Mg, K, etc. is increased in earthworm cast than in the nearby soil.
4. Two to four hundred thousand worms per ha can develop pertinacious structurally stable holes in the soil that permit water infiltration up to 120 mm depth.
5. Each burrow behaves as a mini dam and avoids runoff losses and facilitates the soil to hold the moisture for long duration.
6. The earthworm casting are stable and do not break into smaller fragments, hence avoiding the soil erosion.
7. It is an eco-friendly, nontoxic, and recycled biological product.
8. This compost is an odorless and clean organic matter with different essential nutrients.

Table 10.8 General nutrient contents of oil cakes

Oil cake	Nutrient content (%)		
	N	P_2O_5	K_2O
Nonedible oil cakes			
Castor cake	4.3	1.8	1.3
Cotton seed cake (undecorticated)	3.9	1.8	1.6
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.2
Safflower cake (undecorticated)	4.9	1.4	1.2
Edible oil cakes			
Coconut cake	3.0	1.9	1.8
Cotton seed cake (decorticated)	6.4	2.9	2.2
Groundnut cake	7.3	1.5	1.3
Lin seed cake	4.9	1.4	1.3
Niger cake	4.7	1.8	1.3
Rape seed cake	5.2	1.8	1.2
Safflower cake (decorticated)	7.9	2.2	1.9
Sesame cake	6.2	2.0	1.2

Source: FAI (2012)

10.5.2 Concentrated Organic Manures

Concentrated organic manures include raw materials of animal or plant origin like oil seed cakes, blood meal, fish meal, meat meal, and horn and hoof meal that contain higher level of essential plant nutrients like N, P, and K in contrast to bulky organic manures.

10.5.2.1 Oil Seed Cakes

Oil seed cakes are the by-products of oil seed crops. After the removal of oil from seeds, the residual material is dehydrated as cake that can be implemented as manure. Oil cakes are the imperative and organic nitrogenous manure. It also contains low levels of P and K. The general nutrient contents of oil cakes are shown in Table 10.8. There are two kinds of oil cakes.

10.5.2.1.1 Edible Oil Seed Cakes

This sort of oil cakes is exercised as feed for cattle and includes mustard oil, groundnut, sesame, linseed, cotton oil seed, and coconut cakes.

10.5.2.1.2 Nonedible Oil Seed Cakes

This form of oil cake is not appropriate for feeding the cattle and mostly utilized for manuring crops like castor, neem cakes, etc. The nonedible oil cakes consist of toxic material that makes them inappropriate for feeding the cattle. However, these are excellent sources of N-containing manure. The level of N differs with the nature of oil cake. It varies from 2.5% to 7.9%. Besides N, all oil cakes have low levels of H_3PO_4 (0.8–2.9%) and potash (1.1–2.2%). Oil cakes are not soluble in H_2O. However, their N becomes readily accessible after 10 days of its application to crops.

10.6 Benefits of Organic Manuring in Intensive Agriculture

Application of organic material to crop land can affect soil characteristics. However, the effects usually may not be evident in short-term applications. The easiest way to check the agronomic worth of fine decomposed organic manures is the estimation of supply of organic content and plant growth nutrients. The prolong supply of essential growth substances is important to enhance the crop yields in the succeeding years. However, it is important to generalize the outcomes of organic manures utilization on the soil-plant network.

10.6.1 Effects on Soil Biological, Chemical, and Physical Fertility

There are general standards for physical and chemical characteristics of good (fertile) soil which are also applicable to different types of soils. However, standards for biological characteristics of good soil are difficult to establish. Moreover, as compared to chemical fertility, limited techniques are available to farmers to analyze the soil physical and biological fertility. In organic farming more attention is paid on biological processes because chemical fertility depends on biological processes. Organic amendments influence the physical, chemical, and biological features of soil and thus enhance the crop production described (Abbott and Murphy 2007).

10.6.1.1 Biological Fertility

Soil biological fertility depends on those soil mechanisms that involve direct or indirect microorganism's activity. Root nodulation by bacteria and mycorrhiza fungi directly enhance the plant growth. However, growth may be indirectly influenced by enhancing soil chemical fertility through organic compound mineralization and mineral dissolution and physical fertility like soil aggregation. Soil biological fertility can be counted by determining the size, diversity, and activities of microbial populations. Small changes in management practices affect the microbiological and biochemical soil characteristics to a greater degree. Microorganisms such as bacteria, fungi, actinomycetes, and microalgae significantly contribute to breakdown of organic compounds, nutrient cycle, and other chemical changes in soil. Decomposing microorganisms require organic C as a source of energy; hence organic C should either be assimilated into their cells, discharged as metabolic compounds, or dissipated as CO_2. The growth nutrients N, P, and S existing in the organic compounds are transformed into inorganic form. Afterward, they are either immobilized and utilized in microbial metabolism or mineralized and discharged into the soil nutrient reservoir (Murphy et al. 2007). For the assimilation of decomposed organic deposits, microorganisms require the optimum concentration of N that depends on the C:N ratio of the microbial biomass. The optimum concentration of N essential for microbes is 20 times less as compared to C. In the presence of low level of readily decomposable C compounds and high level of N as compared to that required by the microbial population, the rate of N mineralization will be higher that releases inorganic N. It is problematic to differentiate between the direct and indirect outcomes of an organic amendment on the activities of soil microflora. The activity and growth of autochthonous plants can be enhanced by amending the soil with compost or other organic compounds containing mineral N fertilizer. Different long-term field trials have proved that soil biological characteristics like microbial biomass C and respiration and certain enzymatic activities are exceptionally enhanced by compost amendments mostly in the surface layers of the soil. As decomposition rate of composts is slow in the soil, the persistent supply of nutrients can support microorganisms for longer periods, in contrast to chemical fertilizers (Ros et al. 2006). Generally, the concentration and quality of organic amendment added to soils are the main aspects that control the activity and strength of different microbial population involved in nutrient cycling. It may be recommended that application of organic matter to crop land improves the biological properties of soil, based on the concentration and nature of materials added.

10.6.1.2 Chemical Fertility

The chemical fertility of soil demonstrates its potential to deliver an appropriate chemical and nutritional environment to plants and to assist biological and physical activities. In organic farming, the preservation of soil chemical fertility depends on the processes that convert the nutrients from fixed to soluble forms like mineralization of organic matter and dissolution of minerals. These mechanisms also occur in traditional farming systems, but they are more important in organic farms. Several long-term field experiments demonstrated that application of organic material to soil improved the organic C level and thus improved the cation exchange potential. This outcome can be attributed to negative surface charges of organic matter that is imperative to keep the nutrients and their supply to plants. Soil application of compost and manure for many years result in both increasing and decreasing the pH of soils, depending on their original pH and organic deposits. Soil pH raised by 0.5 units by increasing quantity of dairy manure compost from 11.2 to 179.2 t ha^{-1} (Butler and Muir 2006). Residual effects of long-term application of compost on crop yield and soil characteristics can exist for many years, because the N and other growth substances become available for plants in the first year after application. Numerous microbes transform organic N into inorganic form through mineralization process. N mineralization from compost is inadequate in the short term. However, long-term application of compost has significant effect on N availability and crop yields. Consistent application of manures to soil for many years enhanced the soil N in the surface layers of soil by providing the protection to this nutrient within macroaggregates. The C:N ratio of organic matter is a good sign of nutrient supply. It is acknowledged that when compost having high C:N ratio (more than 30:1) is applied to the soil, then microorganisms compete with plants for soil N, consequently immobilizing it. The application of organic material to soil for many years derived from household wastes and yard trimmings increases the concentration of available K in the soil, because these organic sources are rich in K. In context of P from organic amendments, the application of beef cattle manures to soil also increase the plant available P in the soil (Sodhi et al. 2009). It can be established that long-lasting applications of several organic materials enhance the soil K, P, and organic C and result in prolonged N supply.

10.6.1.3 Physical Fertility

Physical processes and properties influence soil fertility by fluctuating the movement of water through the soil pores, waterlogging, and root penetration of soil. Soil structure and texture are important physical properties of soil that affect soil fertility. Structure depicts the natural aggregation of soil particle and pores in the soil, while texture is the ratio of sand, silt, and clay particle in the soil. Erosion is a physical process that takes away the fertile layer of the soil thus declines the soil fertility. Poor soil structure and loose texture augment the severity of water erosion and waterlogging. Soil salinity also affects the soil physical fertility. But soil salinity is a chemical property which affects the physical fertility by declining the water movement through the soil. Physical fertility of soil promotes the sustainable organic farming by supporting the system in which biological and chemical mechanisms provide essential growth substances to plants and minimize the threat of soil erosion. In organic farming practices, the soil physical fertility is enhanced as compared to traditional practices due to the advantageous effects of added organic material on soil microbes and soil structure. Organic matter improves soil aggregation through enhanced activities of soil organisms. Enhanced soil structure and root development are important in organic farming for efficiently using the growth substances and for preventing N leaching from mineralizing legume deposits. Aggregate stability in soil can be enhanced with organic amendments that can support an appropriate soil structure by improving pore spaces for gas exchange, water holding, and root and microbial growth. Soils in arid and semiarid zones are vulnerable to erosion due to low level of organic matter. Organic matter improves the soil structure by two distinct methods, by enhancing the interparticle cohesion within soil aggregates and by promoting their hydrophobicity, hence reducing their disintegration. Enhanced activity of microbes in the soil due to application of composted material is responsible to increase the stability of soil structure. Various biological binding agents are responsible for aggregate stability. Polysaccharides released by microbes most importantly at the start of organic matter decomposition adsorb the mineral nutrients and improve their intercohesion. Organic materials rich in humic compounds also increase aggregate hydrophobicity of clays. Tejada et al. (2009) documented that application of compost increased the soil structural stability by providing greater levels of humic substances to the soil that is mainly important in formation of clay-organic complex compounds. Long-term application of compost, FYM, and digested sewage sludge decreases the soil bulk density and increases the soil porosity. Excessive C level in the soil promotes the water-holding potential due to the effect of organic compounds on soil aggregation. This rise results in more availability of water to plants and also improves the resistance to drought. It can be concluded that constant applications of organic manure can improve soil physical fertility by boosting aggregate stability.

10.7 Compost and Plant Disease Suppression

Soilborne pathogens involving fungi and oomycetes are the main aspects that restrain the yield of agricultural farms, and it is difficult to suppress them by conventional methods like the use of resistant cultivars and chemical fungicides. Plant diseases due to soilborne pathogens can be suppressed by application of organic manures. However, in some cases the application of compost in soil has increased the incidence of diseases. Bonanomi et al. (2010) reported that organic amendments suppressed the diseases in 45% cases, no significant in 35%, but promote the disease incidence in 20%. Unreliable results enormously impede the practical use of compost for disease suppression in organic farming culture. Compost is produced from different plant and animal sources that result in massive variation in the chemical and microbiological characteristics of the final compost and hence in its disease suppressiveness. Actually, compost is formulated by heterogeneous materials due to the diversity of composting methods, feedstock origin, application rate, and level of maturity. The complicated relationships among these aspects make problematic to calculate the suppressive potential of compost. Significant efforts have been done during the last 10 years to understand the mechanism and indicators of organic amendment suppressiveness. Anyhow, very limited knowledge exists about the associations between the chemical and microbiological properties of compost and disease suppression for different plant-pathogens combinations. An established factor to calculate compost suppressiveness is fluorescein diacetate hydrolases (FDA) activity that includes the esterases, proteases, and lipases, soil enzymes related to organic C cycle (Bonanomi et al. 2010). The problem of disease-causing potential of compost can be minimized by disinfecting the compost material. In disinfection process only pathogens are killed but no damage to the beneficial microbes. Disinfection can be performed by exposure to UV light and sunlight.

10.8 Organic Manuring and Agronomic Crops

10.8.1 Crop Productivity

Organic matter is an essential and crucial element, as it improves soil fertility and crop productivity. In Asian countries, addition of organic matter is most common practice to increase crop yield. Addition of organic matter increases crop yield by increasing FYM rates. Significant increase in the yield of rice and chickpea grain through *Sesbania aculeata* L. incorporation in the growing field has been reported (Singh et al. 2002). Organic farming is beneficial for both developed and developing countries because it is eco-friendly, increases biodiversity, minimizes energy use, uses resources economically, and ultimately increases crop yields without reliance on costly inputs. Microbial activity can be enhanced by adding organic matter and composts in the low productive soils. Organic matter enriched with microbes speeds up biodegradation process. Microbes and earthworms mostly work in a combined manner to produce vermin compost and provide essential macroelements like nitrogen, phosphorus, and potassium as macroelements while calcium, magnesium, iron, molybdenum, zinc, and copper as microelements (Amir and Fouzia 2011). Maize grain yield can be improved up to 17% through combination of compost and manure foliar application respect to conventional maize production system where organic fertilizer and artificial fertilizers were applied in combination (Onduru et al. 2002). Although organic input rates are higher than conventional or synthetic substances, rates of organically produced food are more than the foods produced under traditional crop production system.

In an experiment Chan et al. (2008) compared organic farming with conventional farming system. He observed that use of organic inputs at three different regions was higher (46%, 25%, and 22%) as compared to the conventional crop system and the yield difference was more (55%, 94%, and 82%) between organic and traditional rice-growing systems, respectively. Though organic product's yield is less with more inputs, internationally it is sold at higher prices. It was observed that vegetables have shown maximum potential and responsiveness to organic fertilizers and provide more profit to the farmers. In glass house experiment, tomatoes were grown under medium Metro-Mix 360 (control) in combination with animal manure and vermicompost at various concentrations as (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100%). Atiyeh et al. (2000) revealed that substitution of Metro-Mix 360 with vermicompost (20%) gives higher rates in the market as compared to the rest of the treatments by producing ideal size of fruits. So, it is concluded that organic matter has momentous influence on root and fruit weights of tomato.

Hashemimajd et al. (2004) found that organic manure from dairy animals along with rice hull and treated sewage sludge improve tomato quality and yield by increasing shoot and root dry matter as compared with control (sand and soil mixture). Quality of potato improves when it is grown organically by increasing concentration of dry matter accumulation (up to 23%) without impairing its texture, while potato textures and quality fell down after combined application of commercial N and K fertilizers (Haase et al. 2007). Organic matter responsiveness also depends upon crop varieties. Organically grown potato produced more yield (66% and 46%, respectively) treated with organic matter as compared with conventionally grown potato crop (Mourao et al. 2008). More nitrogen uptake was observed by Virgo and Raja (50.5 and 37.0 kg/ha, respectively) as compared with conventional/mineral fertilizers (27.8% and 21.1%, respectively) application of organic crop (tubers and foliage).

Organic crop production not only improves soil fertility but also improves crop productivity by controlling crop diseases in peas, mustard, and chickpea. Vermicompost also influenced the availability of essential minerals like N, P, K, Ca, and Mg (Tripathi et al. 1999). Vermicompost application at 3 t ha^{-1} to chickpea improves total dry mass accumulation, protein content, and grain yield. Soil microbial activity enhanced nitrogen and phosphorus availability and also increased the succeeding maize crop yield (Jat and Ahlawat 2006). Organic substances like biogas slurry, etc. increased the enzymatic activity and protein contents of crops as maize, gram, and sunflower. More nitrogen concentration was observed during all growth stages of maize gram and sunflower by applying biogas slurry with panchagavya (Somasundaram et al. 2007). Organic materials like FYM, BYM, or poultry manures benefit the soil for a long time as they enhance the productivity and yield of intercrops (maize-bean intercrop) for farmers possessing low landholdings in Eastern Cape of South Africa (Silwana et al. 2007). *Rhizobium leguminosarum* bv. *phaseoli* seed inoculation and farm yard manure mixing in soil improve the rajmash (*Phaseolus vulgaris* L.) yield by enhancing nitrogen fixation (Datta et al. 2006). A 4-year research trial showed no marketable yield differences of various vegetable crops (tomato, bean, cabbage, and zucchini) between organic and conventional farming systems. Differences between yield of organic farming and conventional farming were 10% and 3%, respectively. Described that bean yield was increased (53 g/pot–228 g/pot) by applying urban well-decomposed waste having (0.58–1.9%) nitrogen, (0.45–0.67%) phosphorus, and (1.4–1.8%) potash. Maximum bean growth and yield (228 g/pot) response was recorded with well-decomposed and enriched vermin culture waste.

10.8.2 Crop Quality Attributes

Organic matter increases the yield of crops by improving quality parameters like protein, starch, and oil contents. Vermicomposted vegetable waste was used to assess its influence on biochemical characters of chilies. Protein content (113 mg g^{-1} and 79 mg g^{-1}) at 60 and 90 DAS, respectively, carbohydrate content (15.34 mg g^{-1}) at 60 DAS, and chlorophyll (2.61 mg g^{-1}) and total chlorophyll (3.62 mg g^{-1}) at 60 DAS were found to be maximum with vegetable vermin-composted waste. Higher chlorophyll a contents (1.01 mg g^{-1}) were found at 90 DAS with commercial fertilizer application (Yadav and Vijayakumari 2004). Quality of potato is improved when it is grown organically by increasing concentration of dry matter accumulation (up to 23%) without impairing its texture, while potato textures and quality fell down after combined application of commercial N and K fertilizers (Haase et al. 2007). More nitrogen uptake was observed by Virgo and Raja (50.5 and 37.0 kg/ha, respectively) as compared with conventional/mineral fertilizers (27.8% and 21.1%, respectively) application of organic matter. Maheswari et al. (2004) observed that quality of chili increased by adding organic material in the field and it also increased the rate of the chilies in the market.

10.8.3 Soil Fertility

Soil fertility and productivity can be enhanced by adding organic material in the soil. Organic matter in fully decomposed form is more beneficial for good and better soil fertility; also, rotten and fully decomposed farm yard manure releases essential micro- and macronutrients to the soil solution, which become accessible to the root with more concentrations. For sustainable and higher crop production, organic farming should be adopted which improves the quality and productivity of soil by deploying soil properties on sustainable (Minhas and Sood 1994). Organic farming improves the soil fertility by enhancing soil microbial activity, organic carbon, available phosphorus and potassium, soil pH, and soil porosity, maintaining soil EC level, and also acting as a nutrient reservoir for succeeding crops (Gaur et al. 2002).

Changes in soil pH influence the growing vegetation in the soil. Mixing or incorporation of compost in the soil changed the pH from 6.5 to 6, which reduced the population of broad leaf and grassy weeds by 29% and 78%, respectively (Bulluck et al. 2002). Addition of carbon-containing organic material like rice straw, wood, saw dust, sugarcane trash, and corn cobs improves the soil physicochemical characteristics by enhancing decomposition process of manures, reducing water contents, and increasing C:N ratio. In rice-wheat cropping system, addition of farm yard manure along with green manure maintains the Zn, Fe, Cu, and Mn in higher concentrations (Singh et al. 2002). It was observed that green manuring reduced soil reactions by producing humus and organic acids at initial decomposition stage (Laxminarayana and Patiram 2006).

Urkurkar et al. (2010) stated that nitrogen (100%) for rice (120 kg/ha) and for potato (150 kg/ha) in rice-potato cropping system comes 1/3 each from cow dung, neem cake, and decomposed crop residues and increases 6.3 g kg^{-1} organic carbon over preliminary 5.8 g kg^{-1} as compared to the synthetic fertilizers alone. Nevertheless, accessibility of phosphorus and potassium did not display any noticeable modification subsequently accomplishment of five cropping cycles under organic as well as integrated nutrient approaches.

10.8.4 Soil Biotic Characteristics

Organic matter enhances the microbial activity within the soil profile which ultimately leads toward good crop productivity. Microbes like bacteria, fungi, and actinomycetes present in the compost provide humic acid by stimulating microorganisms in the soil (Gaur et al. 1973). In addition, activity of soil nematodes also controlled by organic compost and played an important in mitigating the pesticides influence by important soil organic and pesticide interaction called sorption. Sorption confines deprivation in addition to mineral transportation in soil. Applied insecticides attached to the soil organic matter or clay particles. These are more persistent due to low mobility and less accessible to microbial degradation (Prasad et al. 1972; Gaur 1975). Activity of heterotrophic bacteria and fungi increased due to the addition of more organic matter in the soil thus activates the soil enzyme responsible for nutrient availability by conversion from unavailable form to available form. Farming practices influence soil's biological, physical, and chemical properties. Soils where organic farming is practiced harbored the dense populations of arthropods, nematodes, protozoa, and bacteria as compared to the soils under conventional farming.

To enhance the soil fertility and bioactive agents, addition of organic matter in the soil is the crucial amendment as it increases the beneficial microorganisms; decreases pathogen population, total soil carbon, and CEC; decreases soil bulk density; and ultimately increases soil fertility by improving soil quality (Bulluck et al. 2002). The National Academy of Agricultural Sciences (NAAS) endorsed a general tactic to enhance efficiency of applied inputs. According to NAAS farmers should adopt integrated nutrient management (INM) and integrated pest management (IPM) approach in cropping systems as an alternative organic farming strategy. Prices of organically produced crops give more income return showed an increased microbial population in rice-pea-gram as compared with rice-wheat cropping system. Crops like wheat, rice, and cowpea showed significant increase in yield when P solubilizers like *Aspergillus awamori*, *Pseudomonas striata*, and *Bacillus polymyxa* are used in field experiments. In general, it is observed that vegetables are more responsive to azotobacterial inoculation than the other crops. Nonetheless, wheat, maize, sorghum, cotton, and *Brassica* crops when grown by using *Azotobacter chrooccocum* culture showed increase in yield which was 0–31% as compared to control.

Growth-enhancing substances produced by *Azotobacter* inoculation gave more seed germination due to extensive root growth. Soil structure improved due to the formation of polysaccharides in the soil (Gaur 2006).

10.9 Challenges for Organic Agriculture

Organic farming is facing several issues regarding adaptation, although it is environment friendly, justifiable, but still not achieving its goal. Most common issues in organic agriculture are:

(i) Tillage practices in organic agriculture.
(ii) Industrialization of organic production system.

In organic agriculture system, some common questions are asked about yield, sustainability, and productivity which depend upon many factors like farmer's interest, farmer background, resources of farmer, and indigenous and state sustenance mechanism. The opposite response could be: does conservative cultivation fulfill the world's food demand? Because more input means more yield, agriculture structures are at present waning to feed the world due to problems with productivity and food distribution, public organization, and thoughtful worries such as poverty, discrimination, and masculinity inequity. Since the 1980s, debates have been started among the researchers to compare organic and traditional agriculture. Yield comparisons were made among crop considering the environmental factors. Publication was made on the basis of research trials as comparison of organic and traditional farming (Mader et al. 2002). Same or more production may be achieved in organic farming as follows:

(i) Yield reduction through adaptation nevertheless recovers later.
(ii) Biodiversity and microbial activity found to be higher in organic agriculture system.
(iii) Yield reduction due to weeds, pests, and diseases. They damage the host crop and animals.
(iv) Accumulation of more nutrients may affect the crop growth by utilizing nutrient resource.
(v) Pesticide infection in organic products, public, and the atmosphere found to be less in organic agriculture.
(vi) True benefits of organic farming are still to be exposed.

Appreciated information about agricultural productivity and performance may be gained after farming system comparison over several years. To expand the conventional farming system, huge government and commercial support has been given for several years for plant and animal germplasm optimization, soil fertility, and pest management system to enhance the crop productivity. For conventional and organic farming comparison system, research has been continuously conducted for agricultural, environmental, and also for social and statistical problems (Powell 2002).

Organic food producers should adopt good and better techniques by keeping in mind the market trend and economics of the farmers. Social, economic, and atmospheric restriction may influence the organic production system. Wes Giblett who is a progressive dairy farmer in Western Australia, recently, explained organic farming as "the aim is to grow topsoil." He highlighted that organic farming can be achieved by adopting good agricultural management techniques as zero tillage, manuring (FYM, BYM, crop residues, etc.), crop rotation, and less use of artificial substances. By adopting organic dairy farming, he supplied to Western Australia in an area of Western Australia 2.5 m sq. km, and it was ten times larger than Germany – with a population of almost 1.5 million. Even though he runs this business in a very successful way, the primary objective of Wes Giblett was to cultivate the topsoil for farming to make organic farming successful and more economical for the poor and small farmers.

Adaptation of organic agriculture depends upon by distinguishing the advantages and disadvantages of organic system, so that farmers can make improvements and transfer valuable knowledge regarding organic farming issues when compared with the conventional farming system. On the other hand, organic agriculture is a beneficial and charming option of many farmers and consumers for improving the productivity and ecological influence of organic cultivation. Generally, success of organic farming depends on the region and demand of the people living in that region. In organic farming, weeds, soil fertility, and health of the living species are major concerns. Besides these, marketing and price regularity of organic food is also a big issue, that's why farmers and growers are looking reluctant to adopt organic agriculture. Government policies are also inadequate. Government policies, research, and extension services in this matter should be inline, and they cooperate themselves.

In conclusion, organic farming is a good and better option for the future generation to make them healthy and more intelligent than the existing ones. Organic farming is more economic and environment friendly for the growers and farmers.

References

Abbott LK, Murphy DV (2007) What is soil biological fertility? In: Abbott LK, Murphy DV (eds) Soil biological fertility-a key to sustainable land use in agriculture. Springer, Berlin/Heidelberg, pp 1–15. ISBN: 978-1-4020-6619-1

Amir K, Fouzia I (2011) Chemical nutrient analysis of different composts (Vermicompost and Pitcompost) and their effect on the growth of a vegetative crop Pisum sativum. Asian J Plant Sci Res 1(1):116–130

Atiyeh RM, Arancon N, Edwards CA, Metzger JD (2000) Influence of earthworm-processed pig manure on the growth and yield of greenhouse tomatoes. Bioresour Technol 75(3):175–180

Boller E, Hani F (2004) Manures and soil amendments: Ideal book on functional biodiversity of the farm level. Biol Fertil Soils 40:2

Bonanomi G, Antignani V, Capodilupo M, Scala F (2010) Identifying the characteristics of organic soil amendments that suppress soilborne plant diseases. Soil Biol Biochem 42:136–144

Breland TA (1995) Green manuring with clover and ryegrass catch crops under sown in spring wheat: effects on soil structure. Soil Use Manag 11:163–165

British Columbia (1998) Agriculture composting handbook, 2nd edn. Ministry of Agriculture and Food

Bulluck LR, Brosius M, Evanylo GK, Ristaino JB (2002) Organic and synthetic fertility amendments influence soil microbial, physical and chemical properties on organic and conventional farms. Appl Soil Ecol 19(2):147–160

Butler TJ, Muir JP (2006) Dairy manure compost improves soil and increases tall wheatgrass yield. Agron J 98:1090–1096

Chan KY, Dorahy C, Wells T (2008) Use of garden organic compost in vegetable production under contrasting soil P status. Aust J Agric Res 59(4):374–382

Cherr C, Scholberg J, Mcsorley R (2006) Green manure approaches to crop production. Agron J 98:302–319

Crowder DW, Reganold JP (2015) Financial competitiveness of organic agriculture on a global scale. Proc Natl Acad Sci U S A 112:7611–7616

Datta N, Rana MC, Sharma RP (2006) Effect of seed inoculation and farm yard manuring on nitrogen balance and yield in Rajmash (Phaseolus vulgaris). Indian J Plant Physiol 11(1):108–112

Donn S, Wheatley RE, McKenzie BM, Loades KW, Hallett PD (2014) Improved soil fertility from compost amendment increases root growth and reinforcement of surface soil on slope. Ecol Eng 71:458–465

Fageria NK (2007) Green manuring in crop production. J Plant Nutr 30:691–719. https://doi.org/10.1080/01904160701289529

FAI (2012) Biofertilizer statistics. The Fertilizer Association of India, New Delhi

Garhwal OP, Fageria MS, Mukherjee S (2007) Integrated nitrogen management in okra (Abelmoschusesculentus (L) Moench) hybrids. Haryana J Hortic Sci 36(1–2):129–130

Gaur AC (1975) All Indian coordinated project on microbiological decomposition and recycling of farm and city wastes. Project report, Indian Council of Agricultural Research, Poona, India

Gaur AC (2006) Handbook of organic farming and biofertilizers. Ambica Book Publication, Jaipur

Gaur AC, Sadasivam KV, Vimal OP, Mathur RS, Kavimandan SK (1973) Studies on the humification of organic matter in a red Rakar soil. Zentralbl Bakteriol 128(1):149–161 1973

Gaur AC, Nilkantan S, Dargan KS (2002) Organic manures. ICAR, New Delhi

Goss MJ, Tubeileh A, Goorahoo D (2013) A review of the use of organic amendments and the risk to human health. Adv Agron 120:275–379

Guo R, Schuchardt F, Li G, Jiang T, Chen T (2012) Effect of aeration rate, C/N ratio and moisture content on the stability and maturity of compost. Bioresour Technol 8:112–171

Haase T, Schuler C, Haase NU, Heb J (2007) Suitability of organic potatoes for industrial processing: effect of agronomical measures on selected quality parameters at harvest and after storage. Potato Res 50(2):115–141

Hashemimajd K, Kalbasi M, Golchin A, Shariatmadari H (2004) Comparison of vermin compost and composts as potting media for growth of tomatoes. J Plant Nutr 27(6):1107–1123

Haynes RJ (2004) The development of bottomland forest restoration in the lower Mississippi alluvial valley. Ecol Restor 22:170–182

Heidmann T, Bent T, Christensen, Svend EO (2002) Changes in soil C and N content in different cropping systems and soil types. In: Greenhouse gas inventories for agriculture in the Nordic countries proceedings from an international workshop, Helsinger, Denmark, 24–25 January 2002

Hodges RD (1991) Soil organic matter, its central position in organic farming. In: Wilson WS (ed) Advances in soil organic matter research: the impact: the impact on agriculture and the environment. Royal Society of Chemistry, Cambridge, pp 355–364

Jat RS, Ahlawat IPS (2006) Direct and residual effect of vermin compost, biofertilizers and phosphorus on soil nutrient dynamics and productivity of chickpea-fodder maize sequence. J Sustain Agric 28(1):41–54

Lal R (2007) Carbon management in agricultural soils. Mitig Adapt Strat Glob Change 12:303–322

Laxminarayana K, Patiram (2006) Effect of integrated use of inorganic, biological and organic manures on rice productivity and soil fertility in ultisols of Mizoram. J Indian Soc Soil Sci 54(2):213–220

Mader P, Fliebach A, Dubois A, Gunst L, Fried P, Niggli U (2002) Soil fertility and biodiversity in organic farming. Science 296:1694–1697

MAFF (1998) The soil code: code of good agricultural practice for the protection of soil. MAF, London

Maheswari TU, Haripriya K, Poonkodi P, Kannan SK (2004) Effect of foliar application of organic nutrients on some quality indices and economics of chilli (Capsicum annum L.). Adv Plant Sci 17(1):259–262

Manivannan N, Udhayakumar G, Gnanadesigan M, Thajuddin N, Daniel T (2015) Effects of biofertilizer enriched vermicompost on the growth parameters of Vignaunguiculata (L). Int J Sci Res 4(10):129–132

Maynard DN, George JH (1997) Knott's handbook for vegetable growers, 5th edn. Wiley, New York. ISBN: 978-0-471-73828-2

Minhas RS, Sood A (1994) Effect of inorganic and organic on yield and nutrients uptake by three crops in rotation in aid alfisol. J Indian Soc Soil Sci 42:27–260

Mourao L, Brito M, Coutinho J (2008) Cultivating the future based-on science, organic crop production. In: Proceedings of the 2nd scientific conference of the International Society of Organic Agriculture Research ISOFAR, Germany, 16th June 2008

Murphy DV, Stockdale EA, Brookes PC, Goulding KWT (2007) Impact of microorganisms on chemical transformation in soil. In: Abbott LK, Murphy DV (eds) Soil biological fertility-a key to sustainable land use in agriculture. Springer, Dordrecht, pp 37–59. ISBN: 978-1-4020-6619-1

Onduru DD, Diop JM, Werf EV, Jager AD (2002) Participatory on-farm comparative assessment of organic and conventional farmer's practices in Kenya. Biol Agric Hortic 19(4):295–314

Perez-Piqueres A, Edel-Hermann V, Alabouvette C, Steinberg C (2006) Response of soil microbial communities to compost amendments. Soil Biol Biochem 38:460–470

Powell J (2002) Proceedings of the UK organic research conference: research in context, 26–28 March 2002. Aberystwyth. Organic Centre Wales, Institute of Rural Studies, University of Wales Aberystwyth, Aberystwyth

Prasad SK, Mishra SD, Gaur AC (1972) Effect of soil amendments on nematodes associated with wheat followed by mung and maize. Indian J Entomol 34:307–311

Protection, EUR 21319 EN/3, 872 p. Office for Official Publications of the European Communities, Luxembourg

Ros M, Klammer S, Knapp B, Aichberger K, Insam H (2006) Long term effects of compost amendment of soil on functional and structural diversity and microbial activity. Soil Use Manag 22:209–218

Scotti RD, Ascoli R, Bonanomi G, Caceres MG, Sultana S, Cozzolino L, Scelza R, Zoina A, Rao MA (2015) Combined use of compost and wood scraps to increase carbon stock and improve

soil quality in intensive farming systems. Eur J Soil Sci 66:463–475. https://doi.org/10.1111/ejss.12248
Shepherd MA, Harrison R, Webb J (2002) Managing soil organic matter – implications for soil structure on organic farms. Special issue of soil use and management. British Society of Soil Science
Silwana TT, Lucas EO, Olaniyan AB (2007) The effects of inorganic and organic fertilizers on the growth and development of component crops in maize/bean intercrop in Eastern Cape of South Africa. J Food Agric Environ 5(1):267–272
Singh SP, Kumar RM, Subbaiah SV (2002) Effect of nitrogen and potassium application on grain yield of hybrid rice (Oryza sativa). In: Proceedings of the 2nd international agronomy congress, vol 1, New Delhi, India
Sodhi GPS, Beri V, Benbi DK (2009) Soil aggregation and distribution of carbon and nitrogen in different fractions under long-term application of compost in rice-wheat system. Soil Tillage Res 30(2):401–422. https://doi.org/10.1016/j.still.2008.12.005
Somasundaram E, Mohamed MA, Thirukkumaran K, Chandrasekaran, Vaiyapuri K, Sathyamoorthi K (2007) Biochemical changes, nitrogen flux and yield of crops due to organic sources of nutrients under maize based cropping system. J Appl Sci Res 3:1724–1729
Soussana JF (2008) Workshop on soil at International conference Organic agriculture and climate change, Entia Clermont, France, 17–18 April 2008
Tejada M, Hernandez MT, Garcia C (2009) Soil restoration using composted plant residues: Effects on soil properties. Soil Tillage Res 102:109–117
Triberti L, Nastri A, Giordani G, Comellini F, Baldoni G, Toderi G (2008) Can mineral and organic fertilization help sequestrate carbon dioxide in cropland? Eur J Agron 29:13–20
Tripathi SC, Chauhan DS, Sharma RK, Dhillon OP (1999) Productivity and economics of different wheat (Triticumaestivum) based cropping sequences. Indian J Agron 44(2):237–241
Urkurkar JS, Chitale S, Tiwari A (2010) Effect of organic v/s chemical nutrient packages on productivity, economics and physical status of soil in rice (Oryza sativa)-Potato (Solanum tuberosum) cropping system in Chhattisgarh. Indian J Agron 55(1):6–10
Van-Camp L, Bujarrabal B, Gentile AR, Jones RJA, Montanarella L, Olazabal C, Selvaradjou SK (2004) Reports of the technical working groups established under the thematic strategy for soil. EUR 21319 EN/5, 872 pp. Office for Official Publications of the European Communities, Luxembourg
Willer H, Klicher L (2009) The world of organic agriculture. In: Willer H, Klicher L (eds) The world of organic sgriculture. Statistics and emerging trends. IFOAM/FiBL/ITC, Bonn/Frick/Geneva
Willer H, Lernoud J (2015) The world of organic agriculture. Summary In: Willer H, Lernoud J (eds) The world of organic agriculture. Statistics and emerging trends. FiBL-IFOAM report, Frick/Bonn, Switzerland/Germany, pp 24–30
Yada RH, Vijayakumari B (2004) Impact of vermicompost on biochemical characters of Chilli (Capsicum annum). J Ecotoxicol Environ Monit 14(1):51–56
Yuda CH, Arry YN, Hariyania P (2016) Biophysical monitoring on the effect on different composition of goat and cow manure on the growth response of maize to support sustainability. Agric Agric Sci Procedia 9(2):118–127