

## A Review on sustainable agriculture development through organic farming-

### Abstract

Sustainable agriculture development through organic farming not only provides food requirements for the current generation in an eco-friendly manner but also provides food for future generations and protects ~~controls~~ our environment. Mainly, quality food is provided by organic farming without negative effects on the health of the soil and the quality of the soil side by side with the environment. Organic farming also helps to produce a larger quantity of food for a huge amount of the Indian population. In current agriculture scenario, huge number of pesticides, fertilizers and synthetic compounds are used in agriculture, which causes adverse impacts on soil health, water hazards, toxic residues increasing in the food chain and animal feed in this manner increasing health problems. The objective of the review paper is to identify synthetic fertilizers and pesticides that can be replaced with natural alternatives as well as to examine how organic farming might promote sustainable agriculture.

**Keywords:** Biofertilizers, Bio-pesticides, Manure, Organic farming and Sustainable agriculture

### Introduction

Approximately 187 countries are engaged in organic agriculture, with India being a prominent one. Organic farming is experiencing rapid growth globally, and India holds a significant position in this sector. According to the FiBL survey (2021), India contributes 30% of the global organic production, encompassing approximately 2.3 million hectares. This involves 2,759,660 farmers, 1,730 organic producers, and 745 traders. Organic farming practices are beneficial for environmental health, promoting biodiversity and ecosystem sustainability. Research indicates that organic farming zones support approximately 30% more plant and wildlife species compared to conventional agricultural systems, primarily due to the reduced application of synthetic fertilizers and pesticides. Conversely, conventional agriculture frequently employs various synthetic agrochemicals to control pests, weeds, and diseases, which can have adverse effects on the environment and biodiversity. ~~Approximately 187 countries are currently working on organic agriculture, with India occupying a similar position. Organic farming is rapidly gaining popularity in agriculture. India plays an important role in organic production. In total organic production, 30% of producers present in~~

**Comment [L1]:** Rephrase the sentence as "Organic farming primarily provides high-quality food without harming soil health or compromising soil quality, while also safeguarding the environment."

**Comment [L2]:** Does the entire huge Indian population avail the organic products?

**Comment [L3]:** Rephrase as "Toxic residues accumulating in the food chain and animal feed contribute to rising health problems."

**Comment [L4]:** Justify this sentence: How the use of synthetic fertilizers and pesticides can be included in the organic farming. Please change into bioinputs or bio-based agricultural inputs

**Comment [L5]:** Change the sentence as "and to explore how organic farming can contribute to the advancement of sustainable agriculture."

India in the world manor 2.30 million hectares, 27,59,660 farmers, 1730 total producers and 745 total traders in India (FiBL survey 2021). Mainly, we can keep our nature clean, green, and rich by following organic farming. If we go to any organic farming area there, we see only the humming of birds, insects and animal movement. Research shows that almost above 30% of plants and wildlife present in organic farming zone as compared to the conventional farming system due to less use of synthetic fertilizers and pesticides. But in modern agriculture systems, different synthetic chemicals i.e., agrochemicals compounds are extensively used for controlling pests, weeds and diseases. Agrochemicals are classified based on their chemical structure into several categories, including synthetic pyrethroids, carbamates, organochlorines, chlorophenols, and organophosphates (Hamza *et al.*, 2016). The World Health Organization (WHO) classifies these agrochemicals based on their median lethal dose (LD50) for rats into categories such as extremely hazardous, very hazardous, moderately hazardous, somewhat hazardous, or acutely harmful (WHO, 2009). The use of agrochemicals in agriculture can enhance crop productivity and better align with the demands of growing human populations. Contingent on the structure of chemicals, agrochemicals are classified into synthetic pyrethroids, carbamates, organochlorines, chlorophenols and organophosphates (Hamza *et al.* 2016). The World Health Organization (WHO) categorizes agrochemicals as either extremely hazardous, very hazardous, moderately hazardous, somewhat hazardous, or acutely harmful, according to the median lethal dose (LD<sub>50</sub>) for rats (WHO survey 2009). Crop productivity increases and more closely matches human demands in greater populations when agrochemicals are used during agricultural operations. The indiscriminate use of agrochemicals adversely impacts human health, threatens biodiversity, and disrupts ecosystems (Elahi *et al.*, 2019). Historically, agriculture has relied on natural resources and farmland as inputs, a practice that dates back to ancient times (Nedumaran and Manida, 2020). Negative effects from synthetic fertilizers and pesticides in conventional farming systems have led some consumers to seek compensation (Kalyan, 2005). Consequently, many have turned to organic farming, which produces goods that are healthier and less harmful to human health. Organic farming not only maintains soil fertility and health but also enhances organic matter concentration, promotes biological activity, supports nitrogen self-sufficiency through biological nitrogen fixation and leguminous crops, and utilizes weed management, livestock waste, and crop residues for organic matter recycling and crop rotation to control pests and diseases (Chhonkar, 2002). The use of agrochemicals consistently and without judgment harms human health, threatens biodiversity, and harms the ecosystem (Elahi *et al.* 2019). Our forefathers have been engaging in agriculture since the

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beginning of time, using farmland and natural resources as input (Nedumaran and Manida 2020). Due to the various negative effects that synthetic fertilizers and pesticides in the system of conventional farming cause, some consumers have received reimbursement (Kalyan 2005). As a result, they switched to organic farming which produces goods that are healthy and non-injurious to human health. Besides maintaining the soil fertility status, soil health, levels of organic matter concentration, the biological activity of fostering soil, self-sufficiency of nitrogen through the biological nitrogen fixation and use of legumes crop, use of weed, wastes of livestock and crop residues in the process of organic matter recycling and crop rotation due to the control of pest and diseases (Chhonkar 2002). To mitigate environmental and health issues, it is advisable to avoid pesticide use and instead adopt organic farming practices (Sharma and Singhvi, 2017). The integration of economic opportunities with environmental protection contributes to sustainable agriculture (Ferella *et al.*, 2019). Firstly, increasing the number of farmers practicing organic farming can reduce the spread of toxic substances and improve human health (Yanakittkul and Aungvaravong, 2017). Secondly, the recycling of organic waste enhances soil organic matter (Ulm *et al.*, 2019). Organic farming offers multiple benefits, including social, environmental, and economic advantages. Some studies have indicated that farmers engaged in both professional and part-time work may be more likely to pause organic farming (Heinze and Vogel, 2017). Organic agriculture relies on sustainable natural resources, utilizing bio-products and crop residues to improve crop yield and soil health while ensuring environmental safety and enhancing livestock production (Epule *et al.*, 2015). Organic foods are generally richer in micronutrients and antioxidants, free from harmful fertilizers, chemicals, and pesticides, and tend to have better taste, contributing to environmental sustainability and balance. As of now, 3.1 million farmers globally have adopted organic cultivation practices across 72.3 million hectares of farmland, with ten leading countries certified for their organic farming areas (Fig 1). Ignore the use of pesticides and instead practice organic farming to reduce environmental and human problems (Sharma and Singhvi 2017). The integration of opportunity of economics and protection of the environment direction to sustainable agriculture (Ferella *et al.* 2019). Firstly, more farmers should practice organic farming, which will reduce the distribution of toxic materials and benefit human health. (Yanakittkul and Aungvaravong 2017) and secondly, soil organic matter increased by the recycling of organic wastes (Ulm *et al.* 2019). Organic farming environs the various conveniences for the representation of society such as the performance of social, environmental and economic. Some experiments showed that farmers who are involved in professional work and part time work are dangling to pause

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the organic farming (Heinze and Vogel 2017). Organic agriculture considers as a form of agriculture in which sustainable resources of natural components are used like the application of all bio-products and crop residues. In this way, natural residues and products are used by farmers of organic farming for improving their crop yield and soil health side by side with environmental safety and producing more milk and meat in animals (Epule *et al.* 2015). Demonstrated micronutrients, the larger quantity of antioxidants, without injurious fertilizers, chemicals, pesticides, good in taste and more other things are contained in organically produced foods generally and it keeps the plant sustainable and controlling environmental balance. Eventually, 3.1 million farmers started their cultivation process organically on the 72.3 million hectares of farmland in the world. Ten top countries are certified in area under organic (Fig 1).

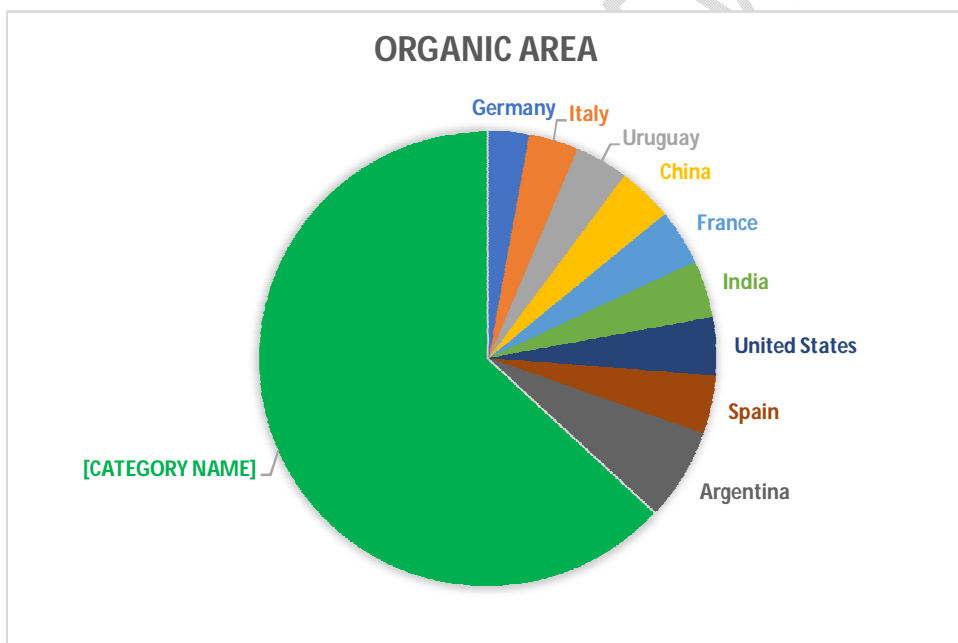


Fig 1. Area under organic farming in top countries (Source: FiBL survey 2021)

Table 1. Exportable organic crops from India

S.No	Commodity Type	Goods
1.	Fruits	Pineapple, orange, banana, passion fruits, cashew and mango

2.	Plantation	Cocoa, tea and coffee
3.	Vegetables	Onion, okra, potato, tomato and brinjal
4.	Pulses	Black gram and red gram
5.	Oil seeds	Sunflower, sesame and castor
6.	Spices	Ginger, nutmeg, turmeric, cardamom, chilli, black paper, vanilla and clove
7.	Nut	Walnut
8.	Others	Herbal extracts and cotton

(Source: APEDA) ~~Table 1. Exportable organic crops from India (Source: APEDA)~~

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### Sustainable Agriculture

Incessantly, many resources and foods are supplied by agriculture for the growing population in the world (Knapp *et al.* 2018). It plays an important role in any activities of human and human existence (Gondchawar and Kawitkar 2016). However, there are a variety of issues that hamper agriculture's ability to meet the needs of people in the present and the future. These issues include land degradation, a high rate of biodiversity loss, climate change, pollution, the depletion of water resources, rising production costs, and a decline in the number of farms. (Peters 2010; Rivera-Ferre *et al.* 2013; Thrupp 2000). Agriculture is not only imperative to deal with these worries, but it is also a major contributor to them given how it has been practiced over the past few decades (Koochafkanet *al.* 2012; Goodland 1997). Sustainable agriculture is a production practice of animals and plants with the application of site-specificity, that will progress over time i.e., satisfy the need for human food and fibre, enhance the quality of the environment, sustain the farm operational economic viability and increase the life of farmers and society as a whole (U.S. Farm Bill 1990).

### Organic Farming in India

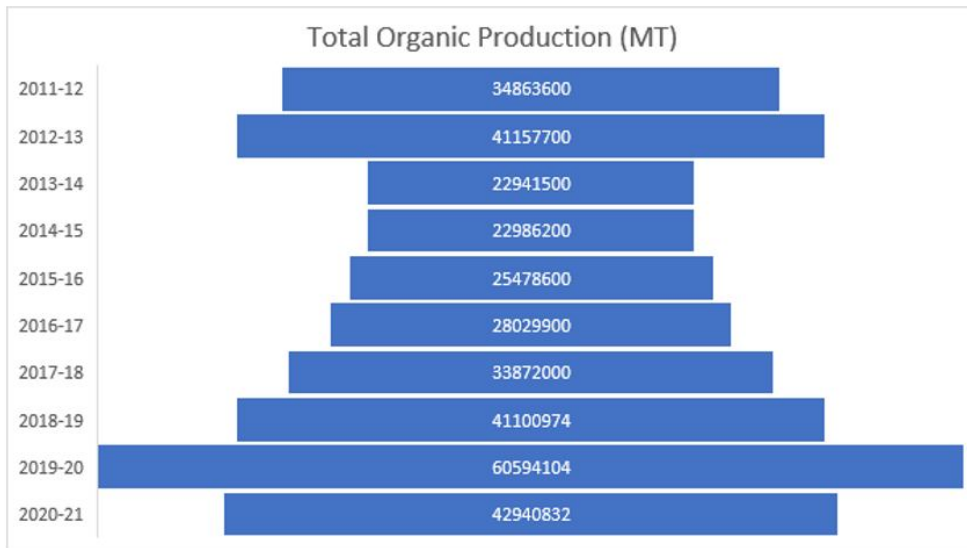
In [India] organic agriculture was promoted by the declaration of Sevagram in 1994, organic farming has raised more laps and this system was strong with the bits of help of initiatives at the governmental and non-governmental levels. The national standard was developed in India by the National Programme for Organic Production (NPOP) and all strategies and support for the promotion of organic farming were done by the National Project on Organic Farming

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(NPOF). In India, organic farming is in incipient generation and 2.30 million hectares of farmlands are cultivated under organic farming conditions. Rajasthan, Madhya Pradesh and Maharashtra – the half cultivated areas of these top three states come under organic cultivation. During the time of the green revolution in 1966, all scenarios in agriculture were changed by the promotion of high yielding varieties and the use of a huge number of fertilizers and pesticides for higher food production and security. Besides, decreasing soil health and increasing the toxicity of food through the application of a larger quantity of synthetic fertilizers and pesticides and making it harmful to consumers. The reasons for adopting organic farming include: firstly, the rapid growth of the organic food industry, which promises increased profitability. Secondly, organic farming supports environmental health and sustainability on social, environmental, and economic levels. Thirdly, it helps to eliminate the use of artificial fertilizers and pesticides that are harmful to human health and degrade the environment. ~~The reasons for organic farming are: firstly, the food industries of organic farming are raising quickly and assuring more~~

~~profitableness. Secondly, to maintain our environment's health and vitality, which is primarily feasible through organic farming on a social, environmental, and economic level. Thirdly, to stop using artificial fertilizers and pesticides that are harmful to human health and deteriorate soil health over time by being ingested through food. Fourthly, achieving a balance between livelihood and environmental health becomes crucial due to the significant negative impacts of conventional agricultural practices. Fourthly, the walkout of the balance between the livelihood and environment turns out to be exceptionally monumental because of the harmful effects caused by the practices of conventional agriculture.~~

**Comment [L8]:** Give percentage of area for each state



**Fig 2. Last 10 years total organic production statistics in India (Source: FiBL survey 2021)**

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### Organic components for plant nutrients

The extensive use of synthetic fertilizers and pesticides boosts crop production but also leads to pollution of air, water, and soil. Consequently, this conventional farming system has increased farmers' concerns about the adequacy and quality of food supply (Vassilev *et al.*, 2015). ~~By the application of a huge amount of synthetic fertilizers and pesticides increases the production of crops besides air, water and soil are also be polluted. Severally, this conventional farming system improved distrust in farmer's minds about a sufficient and quality food supply (Vassilev *et al.* 2015).~~ The addition of organic matter helps maintain soil health and fertility while also enhancing the chemical, physical, and biological characteristics of the soil in an organic agricultural system (Tejada *et al.* 2016). Because of this, farmers started using organic materials, which are explained below.

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### Crop rotation

Crop rotation, or cycling the crops for two or more years on the same plot of land, is the most crucial practice in the organic farming system and this practice helps to reduce pests, diseases, weeds infestation and weed seeds while also improving soil fertility. As an example, if we cultivate leguminous crops in rotation it improves soil fertility status by adding atmospheric N to the soil. (Biernat *et al.* 2020).

## Crop Residues

Crop residues are the residues of the crop left on cultivated land after harvesting the crop.

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~~They not only enhanced erosion control but also sequestered CO<sub>2</sub> in the soil, reduced evaporation losses, increased organic matter concentration, and occasionally served as biofuel (Laamrani *et al.*, 2017; Liang *et al.*, 2012). They not only improved erosion control but also fixed the CO<sub>2</sub> in the soil, reduced the loss of evaporation, increased the concentration of organic matter, and sometimes also used it as biofuel (Laamrani *et al.*, 2017; Liang *et al.*, 2012).~~ When crop residues act as green manure and supply nitrogen in the soil during the growing season of crops, it reduces the use of synthetic fertilizers (Raheem *et al.*, 2019).

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~~Leguminous crops are primarily used as green manure, but they are less suitable for long-duration crops due to the rapid decomposition of their residues and limited nitrogen supply (Rothe *et al.*, 2019). To reduce chemical fertilizer usage, crop residues can be used as green manure, promoting nitrogen fixation and supplying nitrogen through biological decomposition (Zhou *et al.*, 2020). Mainly, leguminous crops are used as green manure crops, but they are not suitable for long duration crops due to the quick decomposition of the crop residues and the short supply of nitrogen (Rothe *et al.*, 2019). Reduce the use of chemical fertilizers for the use of crop residues as green manure through nitrogen fixation and the supply of nitrogen in the process of biological decomposition (Zhou *et al.*, 2020). In this process, crop yields are enhanced by using crop residues as green manure (Subaedah *et al.*, 2016). These residues not only serve as fertilizer but also help control nematodes and weeds without compromising crop yields (Puig *et al.*, 2019). In this process, the yield of the crop increases through the use of crop residues like green manure (Subaedah *et al.*, 2016). Crop residues are not only used as manure but also to control nematodes and weeds without reducing the yield of crops (Puig *et al.*, 2019).~~

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## Organic Manure

Organic manure refers to waste materials from animals and plants that are used to provide essential nutrients to plants (Chhonkar, 2002). Its use in organic farming plays a crucial role in promoting agricultural sustainability (Jiang *et al.*, 2022). Organic manure directly supports crop growth by supplying humic substances and increasing microbial activity, which enhances soil productivity (Aisha *et al.*, 2014). Based on nutrient concentration, organic manure is categorized into two types: bulky organic manure and concentrated organic manure

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(Reddy and Reddy, 2021). Organic manure refers to manure, which is the waste materials of animals and plants that are used to supply nutrients to the plants (Chhonkar 2002). Utilizing organic manure, organic farming contributes significantly to the development of agricultural sustainability. (Jiang *et al.*, 2022). Directly, organic manure helps to promote the growth of the crop due to the supply of humic substances and increases the availability of microorganisms, improving soil productivity (Aisha *et al.* 2014). Depending on the concentration of nutrients, organic manure has two groups, e.g., bulky organic manure and concentrated organic manure (Reddy and Reddy 2021).

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### **Bulky organic manure**

A lower percentage of nutrients are present in bulky organic manures as compared to concentrated organic manures. As a result, a huge amount of bulky organic manure is required for supplying the nutrient in the plants (Sohail *et al.* 2019). Parts of bulky organic manures are farmyard manure (FYM), compost and green manure (Reddy and Reddy 2021).

### **Farmyard manure (FYM)**

A well ~~The nicely~~ decomposed blend of cow dung, urine of the farm animals, litter of the farm and remnant materials of fodder or roughages of cattle are known as farmyard manure. The ~~well nicely~~ decomposed farmyard manure contains 0.5% nitrogen, 0.2% phosphorus and 0.5% potassium (Tandon 1992). Different methods of preparation of FYM are the pit or trench method, box method and heap method.

### **Compost**

The huge amount of waste materials like paddy straw, weeds, sugarcane trash and other waste is converted to compost manure through the decomposition ~~underof an~~ anaerobic process. The well decomposed compost manure contains 0.5 % nitrogen, 0.15 % phosphorus and 0.5 % potassium. Different types of compost are present like town compost, sewage and sludge compost and vermicompost.

### **Green manure**

Green manure refers to the manure which is made by the decomposition of green plant materials. Green manure is made in two ways like green manure crops and green leaf manure. Some important crops for green manure are sunnhemp, dhaincha, sesbania and clusterbeans.

Some weeds also play an important role as green manure crops like Parthenium (*Parthenium hysterophorus*), Water hyacinth (*Eichhornia crassipes*) and Cassia (*Cassia fistula*), etc.

### Concentrated organic manure

A higher percentage of nutrients are present in concentrated organic manure in comparison to bulky organic manure. As a result, a lower amount of organic manure are required to supply

Organic manure	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Sheep and goat manure	3	1	2
Poultry manure	3-6	2-6	1-4
Fish meal	4-10	3-9	0.3-1.5
Raw bone meal	3-4	20-25	-
Meat meal	10-5	2-5	0-5
Steamed bone meal	3-4	20-25	-
Blood meal	10-12	1-2	1-0
Horn and hoof meal	1-3	-	-

plant nutrients. Some important concentrated organic manure is blood meal, oilcake, meat meal, fish meal, horn and hoof meal, steamed bone meal, raw bone meal, poultry manure and sheep and goat manure.

**Table 2. Nutrient percentage of concentrated organic manure based on Livestock**

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<u>Organic manure</u>	<u>Nitrogen (%)</u>	<u>Phosphorus (%)</u>	<u>Potassium (%)</u>
<u>Sheep and goat manure</u>	<u>3</u>	<u>1</u>	<u>2</u>
<u>Poultry manure</u>	<u>3.03</u>	<u>2.63</u>	<u>1.4</u>
<u>Fish meal</u>	<u>4-10</u>	<u>3-9</u>	<u>0.3-1.5</u>
<u>Raw bone meal</u>	<u>3-4</u>	<u>20-25</u>	<u>=</u>
<u>Meat meal</u>	<u>10.5</u>	<u>2.5</u>	<u>0.5</u>
<u>Steamed bone meal</u>	<u>3-4</u>	<u>20-25</u>	<u>=</u>
<u>Blood meal</u>	<u>10-12</u>	<u>1-2</u>	<u>1.0</u>
<u>Horn and hoof meal</u>	<u>13</u>	<u>-</u>	<u>-</u>

**Table 2. Nutrient percentage of concentrated organic manure based on Livestock (Source: Reddy and Reddy 2016)**

**Biofertilizers Fig 3. Different kinds of organic manures**

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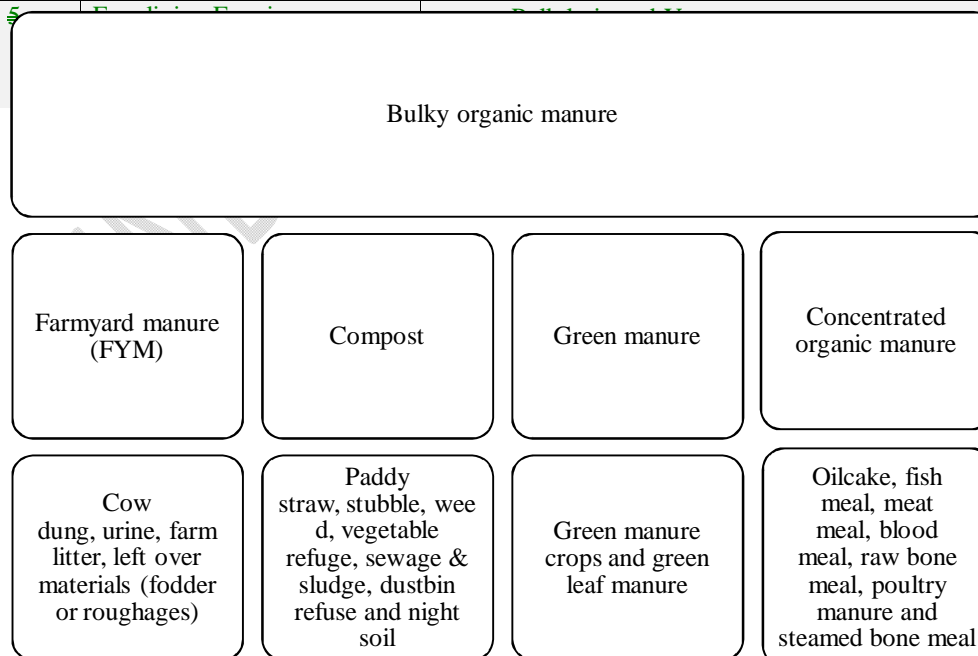
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## Biofertilizers

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Biofertilizers are biological substances that function as fertilizers, enhancing soil fertility by fixing atmospheric nitrogen through the activity of mycorrhizal fungi and bacteria. In addition to nitrogen fixation, they promote crop growth and biomass production. Biofertilizers are classified into two types, including non-symbiotic nitrogen-fixing organisms, which exist freely in the soil or outside plant cells. Biofertilizers refer to biological substances which act as fertilizers and have the ability to increase soil fertility by the fixation

S.No.	Kinds of Bacteria	Example
1.	<del>Aerobic nitrogen fixing bacteria</del>	<ul style="list-style-type: none"> <li><del>Non-photosynthetic: Azomonas, Azotobacter</del></li> <li><del>Photosynthetic: Chromatium, Chlorobium</del></li> </ul>
2.	<del>Anaerobic nitrogen fixing bacteria</del>	<ul style="list-style-type: none"> <li><del>Non-photosynthetic: Clostridium</del></li> <li><del>Photosynthetic: Rhodospirillum</del></li> </ul>
3.	Chemosynthetic bacteria	<ul style="list-style-type: none"> <li>Heterotrophic: <i>Desulfovibrio</i></li> </ul>
4.	Cyanobacteria	<ul style="list-style-type: none"> <li>Heterocyst: <i>Anabaena, Calothrix, Nostoc</i></li> <li>Non-heterocyst: <i>Lyngbya, Oscillatoria</i></li> </ul>



<u>S.No.</u>	<u>Kinds of Bacteria</u>	<u>Example</u>
1.	<u>Aerobic nitrogen-fixing bacteria</u>	<ul style="list-style-type: none"> <li>• <u>Non-photosynthetic: <i>Azomonas, Azotobacter</i></u></li> <li>• <u>Photosynthetic: <i>Chromatium, Chlorobium</i></u></li> </ul>
2.	<u>Anaerobic nitrogen-fixing bacteria</u>	<ul style="list-style-type: none"> <li>• <u>Non-photosynthetic: <i>Clostridium</i></u></li> <li>• <u>Photosynthetic: <i>Rhodospirillum</i></u></li> </ul>
3.	<u>Chemosynthetic bacteria</u>	<ul style="list-style-type: none"> <li>• <u>Heterotrophic: <i>Desulfovibro</i></u></li> </ul>

of atmospheric nitrogen through the activity of mycorrhizal fungi and bacteria. They not only fix the nitrogen but also increase the growth of the crop and produce biomass. Two types of biofertilizers are present in the soil e.g., Non symbiotic nitrogen fixation. Organisms freely present in the soil or stay out of the plant cell are known as non-symbiotic nitrogen.

**Table 3. Non-symbiotic nitrogen fixing bacteria (Source: ~~Plant Physiology and Metabolism by Dr. H.N. Srivastava~~)**

4.	Cyanobacteria	<ul style="list-style-type: none"> <li>• <u>Heterocyst: <i>Anabaena, Calothrix, Nostoc</i></u></li> <li>• <u>Non-heterocyst: <i>Lyngbya, Oscillatoria</i></u></li> </ul>
5.	Free living Fungi	<ul style="list-style-type: none"> <li>• <u>Pullularia and Yeasts</u></li> </ul>

**(Source: Plant Physiology and Metabolism by Dr. H.N. Srivastava)**

### **Nitrogen fixation**

(Source: Plant Physiology and Metabolism by Dr. H.N. Srivastava)

#### **Nitrogen fixation**

These bacteria form close associations with the roots of grasses and cereals to fix nitrogen, a process known as associative nitrogen fixation. Common associative bacteria include *Beijerinckia*, *Azospirillumbrasilense*, and *Azotobacter paspali*. In contrast, symbiotic nitrogen fixation involves a mutualistic relationship between plants and bacteria. This process occurs in three ways: nitrogen fixation through nodule formation in leguminous crops, nodule formation in non-leguminous crops, and nitrogen fixation through non-nodulating mechanisms. These bacteria come into close contact with the roots of grasses and cereals and fix nitrogen. This loose mutualism association is known as associative nitrogen fixation. The associative bacteria in a root are *Beijerinckia*, *Azospirillumbrasilense*, and *Azotobacter paspali*, whereas symbiotic nitrogen fixation refers to the fixation of nitrogen symbiotically and the building of a mutualistic relationship between plants and bacteria. This symbiotic nitrogen fixation occurs in three processes: fixation of nitrogen through the formation of nodules in leguminous crops; fixation of nitrogen through the formation of nodules in non-leguminous crops; and fixation of nitrogen through the non-nodulation process.

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#### **Bio-pesticides**

When pests are controlled and managed by the application of biological products and bio-organisms, those pesticides are known as bio-pesticides. Ecological disturbances arise from the harmful effects on non-target insects caused by the regular use of synthetic pesticides. Additionally, insects develop resistance due to the continuous application of the same synthetic pesticides. Disturbances occur in ecology due to the bad effects on non-targeted insects through the regular application of synthetic pesticides. And developed resistance power in insects due to the continuous application of the same synthetic pesticides (Azeem et al. 2019).



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**Table 5. A few examples of plants with antibacterial properties, together with the target disease and their active components**

Ahmad *et al.* (2017) reported that secondary metabolites with antifungal, antioxidant, antibacterial, or insecticidal effects, including alkaloids, steroids, terpenes, tannins, phenols, resins and flavonoids make up the majority of the prevalent bioactive chemicals in botanical pesticides. The growing demand for natural plant products in the food, agriculture, and medical fields has prompted research into the chemical makeup of substances in many plant families (Jnaid *et al.* 2016; Plata Rueda *et al.* 2017). For instance, *Jatropha carcus* seed kernels are rich in esters, flavonoids and phenolics (Oskoueian *et al.* 2011) While tannins and flavonoids are the main bioactive compounds in the leaves of *Mentha piperita* (Pramila *et al.* 2012). Given plant species are effective against a particular class of pests due to the specific compounds found in those species (Table 5)

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Plant name	Target pathogen	principal active chemical component	References
<i>Allium cepa</i>	<i>Escherichia coli</i>	2,2-diphenyl-1- picrylhydrazyl	Abdel-Salam <i>et al.</i> 2014
<i>Mentha piperita</i>	<i>Staphylococcus aureus</i> , <i>Enterococcus faecium</i> , <i>Bacillus subtilis</i>	neomenthol, menthone, menthol, methyl acetate, acetylmenthol	Sokovic <i>et al.</i> 2010; Pramila <i>et al.</i> 2012; Al-Taweil 2014
<i>Origanum spp.</i>	<i>Micrococcus luteus</i> , <i>Basilluspp</i> , <i>Serratia marcescens</i> , <i>Saprophyticus</i>	Terpinen, Cymene, Thymol, p-Cymene	alpha-Terpinen, o-alpha-Terpieol, Sharoba <i>et al.</i> 2015; Plant and Stephens, 2015; Saaed and Tariq, 2009

<i>Lantana camara</i>	<i>Escherichia coli</i> <i>Klebsiella pneumoniae</i>	9,12,15-octadecatrienoic acid, caryophyllene Hexadecanoic acid, Phytol	Pawar <i>et. al.</i> , 2013; Swamy <i>et. al.</i> , 2015
<i>Citrus spp.</i>	<i>Staphylococcus aureus</i> , <i>Salmonella enterica</i> , <i>Escherichia coli</i> , <i>Pseudomonas putida</i>	<i>Neohesperidin</i> , <i>Eriodictyol</i> , <i>Naringin</i> , <i>Limonene</i> , <i>Naringenin</i> , <i>Tetrazin</i> , <i>Coumarin</i>	Dhanavadeet. <i>al.</i> 2011; Mandalariet. <i>al.</i> 2007

**Table 5. A few examples of plants with antibacterial properties, together with the target disease and their active components**

### Effect of synthetic fertilizers and synthetic chemicals on plants and soil

Contamination of the surface area of water bodies in conjunction with soil fertility and groundwater, reduces crop production and increases the hazard of human inanition due to the use of higher amounts of nitrogen fertilizers (Narayan 2005). Excessive use of synthetic fertilizers that are not uptaken by the plant remains in the soil and may result in water pollution and be harmful to living beings (Rashmi *et al.* 2020). Increases nitrification besides increased soil acidity. Excessive use of synthetic fertilizers causes the deficiency of micronutrients like zinc and manganese (Ojeniyi 1981). The increased decomposition rate of organic matter due to the application of inorganic fertilizers as a result of huge amounts of nutrients lost by gas emission, leaching and fixation from soil (Alimi *et al.* 2007). Use of excessive amounts of inorganic fertilizers results in shattering the soil organisms, decomposers and environment in the soil (Gruhn *et al.* 2000). Nutrient imbalance occurs due to the excessive use of synthetic fertilizers resulting in less production of crops (Ojeniyi 2002). Soil health is disintegrated by the over cropping on a long-term basis and continuous use of synthetic fertilizers and synthetic chemicals without the input of organic matter and environmental pollution also occurs (Albiachet *et al.* 2000). Long-term use of synthetic fertilizers can change the soil pH, increase acidification, causes pests and crusting problems in the soil which are influenced by

the low amount of organic matter and humus in the soil, as a result of decrease the microbial activity and stunted growth of the plants (Pahalviet *et al.* 2021).

### **Benefits of Organic farming**

*The application of organic manures enhances soil health (Mensik *et al.*, 2018). Additionally, the use of organic manures, along with organic farming practices, helps reduce environmental pollution and supports environmental health (Panhwar *et al.*, 2019). Increasing soil health due to the application of organic manures (Mensik *et al.* 2018). Reducing environmental pollution and maintaining the health of the environment through the use of organic manures and followed through organic farming (Panhwar *et al.* 2019). Increasing the production of agricultural products with the help of organic farming in a sustainable way (Timsina 2018). Enhancing soil fertility and productivity by maintaining the C:N ratio in the soil due to the application of organic materials (Yu *et al.* 2020). Organically produced products generated attention in both consumer's and producer's minds due to their nutritional quality (Magnusson *et al.* 2003). The larger dry matter contained in the organically produced tuber and leafy vegetables as compared to a product of conventionally produced (Bourn and Prescott 2002). Lesser protein is contained in the organically produced cereals but lysine contained in wheat is higher over the conventionally produced cereals and wheat (Brandt *et al.* 2000). Organically produced products contained higher dry matter, antioxidants and minerals but no presence of residue parts of pesticides as compared to conventionally produced products (Lairon 2010). Organically produced tomatoes contain high amount of salicylic acid as compared to conventionally produced tomatoes (Rossi *et al.* 2008). Organically produced products are produced without the use of pesticides so, no pesticide residue is present in these products (Lung *et al.* 2001). In addition to not having any negative effects on environmental contamination, organic agricultural systems have a protective aspect for the preservation of the environment (Oquist *et al.* 2007). Higher water holding capacity and good soil health and produced higher yield due to the following of organic farming system (Pimentel *et al.* 2005). Much labour is required for the cultivation of organic farming and the job of income generating create in farms (Halberg 2008). Costs of organic products are 10-40% extra as compared to conventional products (Winter and Devis 2006). 30 % more jobs are generated in organic farming systems in rural areas and gain higher output (Pandey and Singh 2012). The balance and interdependence of plants, nutrients, soil microbes, the environment, and humans are the primary goals of the organic farming system (Berova *et al.* 2010).*

**Comment [L11]:** Change the content of this sub section into meaningful sentence with uniform flow.

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**Comment [L12]:** Sentence formation is poor. Try to change into complex sentences.

### Effect of organic materials on crop productivity

A recent meta-analysis in the coverage of global data displays that crop yield of organic farming is on the mean of 60-65% (Seufert *et al.* 2012), 80% (De Ponti *et al.* 2012) and 81% (Ponisio *et al.* 2015) yield of conventional. Organic materials in liquid form contain fewer growth stimulants and nutrients, which serve as a foundational element for reviving the growth cycle by reducing chemical, physiological, and physical imbalances (Natarajan 2002). The grain output of rice and chickpea significantly increased by the application of Dhaincha (*Sesbania aculeata* L.) in organic farming (Singh *et al.* 2001). As reported by a number of researchers, earthworm activity is higher in organically managed fields than it is in inorganic agriculture (Edwards and Lofty 1974). Earthworms and microbes interact during the biodegradation process to produce vermicompost, which is worm faeces mixed with worm castings. Microelements including Fe, Mo, Zn, and Cu, as well as macroelements like N, P, K, Ca, and Mg, were provided by vermicompost (Amir and Fouzia 2011). Nitrogen, phosphorus, and potassium, in that order, made up 0.74, 0.97, and 0.45 percent of the vermicompost (Kumar *et al.* 2021). In low-potential areas, compost and liquid manure top dressing practices for growing maize performed much better than the practices used by conventional farmers today, which mix the application of manure and mineral fertilizers and the grain yields of maize were 11–17% greater than those produced using traditional methods (Onduru *et al.* 2002). According to Tamaki *et al.* (2002), continuous organic farming resulted in superior rice growth than conventional farming. Chan *et al.* (2008) proposed that in three distinct places, the input for growing organic rice was 46, 25, and 22% higher than for growing conventional rice, yet the resulting yields were only 55, 94, and 82% of conventional rice output, respectively. However, the higher premium prices of organically grown crops in the markets make up for the cost of lower yield with higher inputs. With the usage of organic fertilizers throughout time, a steady rise in grain output was seen (Surekha 2007).

**Table 6. Effect of organic materials on crops productivity**

Crop	Nutrients	Reaction	References
Cowpea ( <i>Vigna unguiculata</i> )	N, P, K, Ca <sup>2+</sup> , Mg <sup>2+</sup> , Fe, Zn and Cu	Enhanced the availability of P, K, Fe and decreased total nitrogen in the organic farming systems over the conventional farming systems.	Suja <i>et al.</i> (2017)

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<b>Rice (<i>Oryza sativa</i>)</b>	N, P, K and micronutrients	The higher straw yield was obtained by the application of organic materials as compared to apply of only chemical fertilizers.	Khursheed <i>et al.</i> (2013)
<b>Wheat (<i>Triticum aestivum</i>), Potato (<i>Solanum tuberosum</i>) and Clover (<i>Trifolium sp.</i>)</b>	P, K, Mg <sup>2+</sup> and Ca <sup>2+</sup>	The larger Mg <sup>2+</sup> and Ca <sup>2+</sup> availability in the farming systems of organic farming as compared to conventional farming.	Mader <i>et al.</i> (2002)
<b>Cashew (<i>Anacardium occidentale</i>)</b>	Nitrogen	Availability of nitrogen was high (435 kg ha <sup>-1</sup> ) in case of organic farming over conventional farming (402 kg ha <sup>-1</sup> ).	Mangalassery <i>et al.</i> (2019)
<b>Citrus (<i>Citrus x sinensis</i>)</b>	Nitrogen	2 ton ha <sup>-1</sup> more nitrogen present and 0-100 cm stocked in organic farming system than in the system of conventional farming.	Escanhoela <i>et al.</i> (2019)

**Table 6. Effect of organic materials on crops productivity**

### Effect of organic materials on soil fertility and biological properties

Organic carbon in soil, deposition of heavy metals, depletion of nutrients and soil compaction are affected by the pressures which is made by humans in agricultural soil (Smith *et al.* 2016). Organic carbon in the soil is mainly present in higher amounts in case of organic farming systems as compared to the conventional farming systems and side by side recycling of the organic matter and crop rotation with the leguminous forage crops in organic agriculture (Gattinger *et al.* 2012). Researchwork was completed by Diacono and Montemurro (2010) and they reported that levels of organic carbon in the soil increased by enhancing yield which leading to an increase in crop residue and organic waste. Increasing the production and yield of crops by the application of organic materials as fertilizers and these materials increased the soil organic matter and long term sustainability of nutrients in soils (Oelofsee *et al.* 2013). Rural and urban waste materials are used as compost making materials but waste materials in urban areas are toxic due to containing heavy metals which creates problems for living beings (Rupani *et al.* 2019). Ansari and Kumar (2010) reported that organic carbon in soil increases with the application of vermicompost and vermin-wash in soil. N, P, K, Ca, Mg, Cu, Zn and Fe nutrients are contents highly in use of chemical fertilizers treatments followed by vermicompost and vermin-wash treatments (Ramesh *et al.* 2010). According to Tharmaraj *et al.* (2011) proposed that enhanced the chemical properties (EC and PH), physical

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properties (moisture content, porosity and water holding capacity) and soil fertility (N, P, K, Mg and Ca) of soil by the application of vermicompost along with spraying of vermiwash as compared to the application of chemical fertilizers. An experiment was done by Dubey *et al.* (2014) and they reported that in the case of 100 % organic farming system soil contains a good amount of nitrogen and organic carbon side by side controlling the content of potassium and phosphorus in soil in the initial stage. On ~~but another~~ hand, 100 % inorganic farming system soil contains enough amount of nitrogen and organic carbon besides less amount of potassium and phosphorus seen in the initial stage. A higher number of bacteria is present in the case of organic farming soil (Kumari *et al.* 2017). Trialwork was carried out by Baishya *et al.* (2015) and they proposed that momentous enhancement in soil nitrogen, organic carbon, potassium and phosphorus after harvesting the crop due to the application of 2.5 ton ha<sup>-1</sup> poultry manure. The higher amount of organic matter in the soil, the biomass of microbes and activity of enzymes on saline soil were increased by the application of compost, prepared by municipal solid waste and palm wastes but some activity was reduced in case of higher application of compost (150 ton ha<sup>-1</sup>) (Ouni *et al.* 2013).

### Conclusion

The posture problem of the environment is due to the excessive use of synthetic or chemical fertilizers and pesticides in the conventional farming system for supplying the food demanded by the present generation. Due to this reason, many countries reduced their use of chemical fertilizers and started to practice organic farming. Organic farming requires more effort and time for adoption as compared to conventional farming. The physical, chemical, and biological properties of soil increase with the application of organic materials in the long term and farmer's income also increases. For developing sustainable agriculture, organic farming is the most important factor. ~~I want everyone to practice organic farming.~~

**Comment [L13]:** Scientific points can be added to conclude this review

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