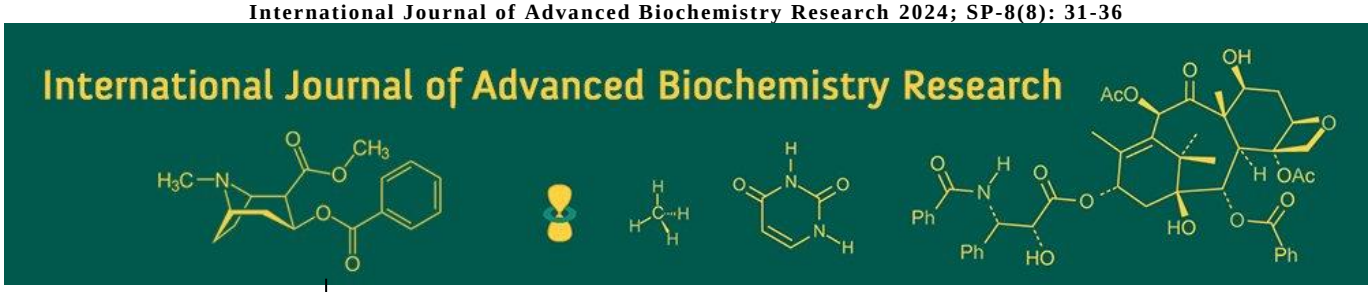

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Organic farming: Making way towards healthy living

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Abstract
Agriculture is crucial for both developed and developing countries. To produce enough healthy food sustainably, eco-friendly farming methods are necessary. Organic farming has gained attention for its ability to address the challenges of conventional farming and mitigate the effects of climate change. The principles of organic farming encompass sustainable soil management, crop diversity, and natural pest control methods. Practices such as crop rotation, composting, and biological pest control are commonly used in organic farming. By adopting innovative and sustainable approaches, farmers can improve productivity and quality of life while protecting the environment.

Keywords: Organic farming, conventional farming, sustainable soil management and biological pest control

Introduction
Agriculture and related industries play a critical role in enriching most developing and developed countries (Bennett *et al*., 2013; Christiaensen *et al*., 2011; Dubey *et al*., 2022) [3, 6, 7]. The growing need for agricultural products has become a source of income for many individuals worldwide (Mathlouthi *et al*., 2022) [25]. However, due to rapid urbanization and population increase, the land available for agriculture is decreasing. India's current population is estimated to be 1.44 billion and is expected to reach 1.64 billion by 2050. This poses a challenge in feeding the increasing population with decreasing cultivable land, leading to unsustainable practices with negative effects on the environment and human health.

The Green Revolution in India, starting in the 1960s, led to significant agricultural achievements, transforming the country from food deficiency to self-sufficiency. However, the indiscriminate use of excessive chemicals during this period raised concerns about the sustainability of agriculture in the long run, calling for sustainable production methods that address soil health, human health, and environmental well-being. Efforts are ongoing to explore alternatives for farming without excessive chemical use.It is important to note that while the emphasis today is solely on productivity, the wider impacts on the land, the food, and the communities are often overlooked. The best agricultural land has already been farmed and has exceeded its safe limits, leaving few natural resources available for further expansion. In response to these challenges, organic farming is recognized as a viable alternative that can function within a friendly ecosystem while sustaining and increasing productivity (Gamage *et al*., 2023) [11].

Organic farming promotes sustainable and environmentally friendly management, conservation practices, and restoration activities, fulfilling many of the requirements for successful adaptation strategies (Muller, 2009; Murmu *et al*., 2022) [28, 29]. Sustainable agriculture, which balances environmental, social, and economic considerations, is vital for meeting current needs without jeopardizing future generations' ability to do the same (Malik *et al*., 2020) [24]. In 2019, India was the world's largest producer of organic foods, with 1.4 million organic food producers, outnumbering the combined number of producers from the world's next nine largest countries. Organic farming is recognized as less polluting than conventional farming in terms of environmental and climate change effects (Sean, 2020) [34].

Principles of Organic Farming

The International Federation of Organic Agriculture Movements (IFOAM) has formulated four broad principles of organic farming, which are the basic roots for the growth and development of organic agriculture in a global context.

1. **Health:** To maintain and improve the health of soil, plants, animals, humans, and the planet as a unified and indivisible system.
2. **Ecology:** Achieving ecological balance by designing farming systems, establishing habitats, and preserving genetic and agricultural diversity.
3. **Fairness:** Ensuring fairness through equity, respect, justice, and stewardship of the shared world, regarding the common environment and life opportunities.
4. **Care:** Managing resources in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment by adopting suitable technologies and avoiding unpredictable ones, such as genetic engineering (Asmita and Ansari, 2019) [2].

Key components vital to organic farming include soil health, plant health, plant protection, and agricultural technologies.

Soil health

The overuse of chemicals leads to a reduction in natural soil fertility, destruction of soil structure, erosion, loss of beneficial microbes, groundwater pollution and depletion, atmospheric pollution, soil acidification, chemical burn, and mineral depletion. Since soil is a nonrenewable resource, sustainable farming aims to protect and preserve soil health. It's important to safeguard soil fertility for future generations while also ensuring the current generation has enough food. Organic farmers employ various techniques to enhance and maintain biological diversity while preserving high soil fertility. There are several ways to improve and restore soil health, which is beneficial for organic farming.

1. Bio-manures: Farmyard manure (FYM) is a rich source of nutrients and organic matter, containing dung, urine, straw, and farm waste. Additionally, concentrated organic manures such as non-edible oil cake, edible oil cake, fish meal bones, poultry, sheep/goat manure, etc., serve as a soil-conserving material. For example, Multiplex Annapurna is one such product. In-situ green manuring with plants like dhaincha, berseem, sunhemp, cowpea, green gram, glyricidia, or sesbania can increase green plant mass in the soil, thereby improving its physical and chemical properties and fertility level. Furthermore, green manuring with leguminous crops can partially substitute FYM, as mentioned by Krishnaprabu, S. in 2019 [21].

2. Composting: Conventional compost is prepared from aerobically decomposed organic waste such as animal dung, plant debris, crop and fodder residues, and weeds left in the field or on the field borders. It also includes raw manure, decaying and rotting vegetables (Krishnaprabu, 2019) [21].
Vermicompost is an organic manure or compost produced by the use of earthworms, which feed on organic matter and excrete it in a finely digested manner. The best species of earthworms for vermicomposting are Eisenia foetida and Eudrilus euginea. Vermicompost is rich in macro and micronutrients, vitamins, growth hormones, and beneficial microflora essential for plant growth (Nagavallemm, *et al*., 2005) [30]. For example, Multiplex Parampara (Vermicompost).

3. Jeevamruta: In recent years, organic farmers have been using an innovative method involving a liquid biological culture called "Jeevamruta." This culture enhances microbial activity in the soil, leading to improved soil fertility. Farmers can conveniently prepare Jeevamruta on their own farms by mixing cattle dung, cattle urine, a small quantity of jaggery, and pulse flour, and leaving the mixture to incubate. Jeevamruta can be used in various crops through soil application, irrigation water, or regular sprayers without any detrimental effects on the crops at any stage, demonstrating the versatility of this liquid microbial culture (Joshi, 2016) [18].

Plant health

Plant health depends on preventive and indirect management measures as well as plant nutrition, which comes from feeding the soil and enhancing soil quality rather than directly feeding the plant. An organic product with the potential to promote growth and provide immunity in plants is called “Panchagavya”. It is made up of nine ingredients: cow dung, cow urine, milk, curd, jaggery, ghee, banana, tender coconut, and water. When mixed appropriately and used, these ingredients have miraculous effects. The physico-chemical properties of Panchagavya show that it contains almost all the major nutrients, micro-nutrients, and growth hormones (IAA & GA) required for crop growth. The application of Panchgavya mixed with carbendazim was found to be effective in suppressing seedling disease and wilt incidence of tomato in both pot culture and field studies (Bhaskar, 1994) [4]. Research on the management of Panama disease of banana caused by 23 Fusarium oxysporum f.sp. cubense, using a modified Panchagavya mixture (a mixture of cow milk, curd, ghee, dung and urine supplemented with yeast and common salt) was reviewed by Jahagirdar *et al*. (2003) [15].

Plant protection in organic agriculture

Pest management is the most challenging part in organic farming as the goal is to prevent pests from reaching economically damaging levels without causing risk to the environment (Chand and Wani, 2017) [5].

In organic farming pest management can be achieved by

1. Trap Crops: Trap crops are used to attract insect pest species away from the main or cash crop in order to protect the main crop and to then destroy the pests. Depending on the target pest and the main crop, trap crops can be planted with or around the perimeter of the cash crop field. Some trap crops are planted within the field of the crop. Another method involves planting at least two rows of the trap crop around the entire perimeter of the cash crop, which is called 'perimeter trap cropping'. Srinivasan and Krishna Moorthy (1992) [35] reported that growing paired rows of mustard with every 25 rows of cabbage has been used as a successful trap crop against diamondback moth in crucifers.

2. Botanicals: Botanicals have been used for ages, and their use has been described in ancient Indian Vedic literature. In addition to this, modern research literature is also available for using botanicals against field pests (Satpathy, 2002) [33] as well as storage pests (Joshi and Tiwari, 2019) [17].

Application of naturally available indigenous plant materials and their products such as neem seed kernel extract, water extract of neem leaves, and other neem products (Multiplex Multineem, Mahan neem powder, Neempure in pellet form), along with chillies and medicinal plants, have been recommended for several crops (Gahukar, 2010) [9].

3. Biological Control: Predators and parasitoids are used to reduce the impact of damage caused by pests in biological control. There are three options to adopt biological control practices, namely classical biological control, conservation and augmentation, which are self-sustaining among themselves. Major groups of predators belong to the orders Hemiptera, Neuroptera, Diptera, Coleoptera, and Hymenoptera, as well as the Arachnida; while parasitoids are mainly present in the orders Hymenoptera and Diptera.

4. Pheromone Trap: Pheromones are chemicals released into the environment in small amounts by special abdominal glands in insects. They are compounds used by insects for intra-species communication, i.e., they are species-specific and may stimulate one gender or both genders. Pheromone traps are designed based on the flight nature of particular insect pests. Synthetic pheromones are manufactured and used as lures. Pheromone traps are used for monitoring and effectively managing the target pests. Based on their effect, pheromones can be divided into Aggregation pheromones, Alarm pheromones, Sex pheromones, Trail pheromones, and Marking pheromones. Multiplex Group of Companies has developed pheromone traps under different brand names such as Aakarshan, Tutakarsh, Delta Trap, Fall-out, and Pink-B.

5. Crop Rotation: Crop rotation is a farming practice in which different crops, mainly from the families Cruciferaceae, Solanaceae, Leguminoseae, Alliacea, Cucurbitaceae, and Umbelliferacea, are grown in the same field at different time periods (Mudgal, 2010) [27]. In this farming practice, avoid the families of vegetables that share similar pests and diseases. Rotating different plant families can help in breaking the life cycle of many pests and diseases, creates diversity, builds soil organic matter and provides nutrients, provides economic value to the farm, and improves sustainability and soil health.

6. Multi-cropping: Involves the simultaneous cultivation of two or more crops. In Indian agricultural tradition, farmers have been known to sow as many as 15 types of crops at one time. An example of multi-cropping is planting tomatoes, onions, and marigold together, where the marigold helps repel some of the tomato's pests (Chand, S., & Wani, S. A. 2017) [5].

7. Inter-cropping: On the other hand, is the cultivation of another crop in the spaces available between the main crop. A good example is the multi-tier system of planting coconut, banana, and pineapple/ginger/leguminous fodder/medicinal aromatic plants. Inter-cropping ensures biodiversity within a farm and allows for the maximum use of resources (Chand, S., & Wani, S. A. 2017) [5].

New vistas enhancing organic farming

Modern agriculture is a constantly evolving approach to agricultural innovations and farming practices. It is based on the use of high-yielding varieties of seeds, biotechnology, and technology (Gamage *et al*., 2022) [10]. A combination of organic farming and new technologies is crucial to overcome the limitations and challenges of organic farming. The innovative and sustainable approach of organic farming enhances agricultural productivity and improves the quality of life for many farmers in an environmentally friendly way (Gamage *et al*., 2023) [11].

1. Biofertilizers: Biofertilizers are living microorganisms of bacterial, fungal, and algal origin that are environmentally friendly and beneficial to agriculture. They improve soil fertility and crop productivity by supplying nutrients and enhancing the availability of unavailable forms of nutrients. Biofertilizers consist of several bacteria, fungi, and actinomycetes. Key examples include Rhizobia, Azotobacter, Azospirillium, blue-green algae, Azolla, and phosphate solubilizers (various bacteria and fungi) as well as products like Multiplex Sunirise, Azab, Madhu, Trishul, Durga, Shakti, Nalpak, and Organic Magik. Their role in supplementing nutrition makes them ideally suitable for integrated nutrient management systems and organic farming. According to Kumar *et al*. (2017) [23], the application of bio-organic fertilizer improved soil organic carbon by 6–13%, along with an increased number of plant growth-promoting bacteria compared to using only chemical fertilizers. Mycorrhizae is a symbiotic association between a fungus and a plant, and mycorrhizal biotechnology is a major component of sustainable organic farming. Over the last 30 years, numerous reports have indicated and appreciated the manifold benefits of biofertilizers, such as protecting plants against soil-borne plant pathogenic fungi, viruses, and nematodes.

2. Biopesticides: Biopesticides consist of living organisms or natural products derived from them. Examples include plants such as Pyrethrum -Chrysanthemum sp. and neem *Azadirachta* or *Melia* sp., macrobials such as *Trichogramma* parasitoid and *Cryptolaemus montrouzieri*, as well as microscopic organisms like nematodes and microorganisms including bacteria, viruses, and fungi. Transgenic plants containing a pest-combating gene, like Bt cotton, also fall under biopesticides. Their key advantages include safety for mammals and non-target organisms, environmental compatibility, target specificity, lower exposure to pests, support for integrated pest management with chemical pesticides, and acceptability for use in organic agriculture. Some examples of biopesticides include Bt formulations to control lepidopteran species, *Trichoderma* sp for controlling soil fungi and as a plant growth regulator, *Verticillium lecanii* for controlling whiteflies, aphids, thrips, and other sucking pests, *Beauveria bassiana* for controlling thrips and other insect pests, *Paecilomyces fumosoroseus* for controlling beetles, fire ants, and nematodes, and *Corynebacterium paurometabolum* to control nematodes and other pests. *Metarhizium anisopliae* can be used to control termites, various coleopteran insects, leafhoppers, and aphids (Chand and Wani, 2017) [5]. Example: Nisarga, Minchu, Baba, Varsha, Metarhizium etc.

3. Biochar: Is produced from various carbon-rich biomass sources including animal wastes, food wastes, sludge, industrial wastes, wood chips, agricultural wastes, and forestry residues, all of which have different chemical and

physical properties. The most commonly used method for producing biochar from biomass is pyrolysis (Kukreti *et al*., 2021) [22]. When chemical fertilizers are coated with biochar, it helps reduce water pollution caused by inorganic fertilizers (Glaser *et al*., 2015; Agu *et al*., 2022; Gamage *et al*., 2022) [13, 1, 10].

4. Sludge: Is a semi-solid slurry that can be generated from a variety of industrial, water treatment, wastewater treatment, or on-site sanitation processes. It contains valuable organic matter and essential nutrients such as nitrogen and phosphorus, making it suitable for use as an organic fertilizer or soil conditioner. Research has shown that using sewage sludge as organic fertilizer can increase the economic yield of wheat and improve soil productivity (Khan *et al*., 2006) [19].

5. Technological innovations: Agricultural machines are designed for various stages of the agricultural process. They include machines for tilling soil, planting saplings, irrigating farmland, spraying, harvesting, and post-harvest processes. Drones, such as the Multiplex M drone, are increasingly useful in crop management. Trained farmers can use sensor-equipped drones to monitor plant growth, detect disease stress, monitor field temperature, and spray pesticides or fertilizers at desired locations in the field (Multiplex Yuktix).

Hydroponic farming, a soilless cultivation method, and vertical farming, growing crops in vertically stacked layers, are gaining attention due to the loss of topsoil and their suitability for urban farming. Agricultural sensors, durable and moderately inexpensive, provide real-time information to farmers regarding crops, soil moisture, nutrient deficiency, plant infections, and pest attacks.Data from satellite images, sensors, and IoT devices facilitate smarter decisions to optimize farm operations by using minimal resources and mitigating risks to achieve optimal crop yields. Precision agriculture, a rapidly evolving farm management system, involves the use of sensor technology, AI, GIS, and IoT to collect and analyze data about soil, plants, and animals. This allows for more targeted use of inputs such as water, fertilizer, plant nutrients, pesticides, seeds, and labor. Satellite images can be used for various types of information, such as monitoring weather changes and road networks. Advances in electronic nose sensors (e-noses) have opened new avenues for monitoring and detecting plant diseases and pests through the analysis of emitted volatile organic compounds. Traceability in agriculture makes agri-supply chains more transparent and provides farmers with increased control over operations and quality compliance through e-commerce. Easy internet access has helped farmers and agri-enterprises in self-learning and upgrading themselves to new technologies. This competitive edge helps improve their access to local and international markets, leading to better price realization. Different agriculture-related applications provide a platform for a better understanding of farming, updates on government schemes, weather forecasts, and other relevant information. Various Artificial Intelligence (AI) tools provide solutions based on data that indicates the type of crop harvest and suitable soil types. Governments are using these AI tools to reduce the time needed to settle farmers' claims.

Government Scheme that Promote Organic Farming

1. National Mission for Sustainable Agriculture (NMSA)
2. Mission for Integrated Development and Horticulture (MIDH)
3. Rashtriya Krishi Vikas Yojana (RKVY)
4. National Project on Organic Farming (NPOF)
5. National Programme on Organic Production (NPOP)
6. National Horticulture Mission (NHM)
7. Horticulture Mission for North East and Himalayan States (HMNEH)
8. Macro-Management of Agriculture (MMA)
9. National Project on Management of Soil Health and Fertility (NPMSHF)

Conclusion

The Indian Agriculture was traditionally organic and farmers were following organic cultivation till the middle of the last century (1950). Organic farming is practiced across almost all states in India with Sikkim formally declared a 100 percent organic state in 2016. Other states, such as Meghalaya, Mizoram, Uttarakhand, Goa, and Sikkim, have 10 percent or more of their net sown area under organic. There is no information available on the number of uncertified organic farmers in India. Organic products are richer in nutrients and largely free of pesticide residues and additives. Organic farming isn't necessarily the best option for long-term agriculture and food security, but judicious mixtures of organic and conventional practices could help boost global agriculture output. Sustainable agriculture also offers a way for agricultural approaches to support an increasing population while adapting to changing environmental conditions. Sustainable farming is important because it offers solutions for the contemporary issues of traditional farming. In other words, organic farming mirrors the sustainability concepts of Global Agriculture. A combination of new farming inclusions like advance technologies, continued research and amendments in policies are of utmost importance to reduce the limitations and challenges of organic farming. Organic farming is practiced in 187 countries, with at least 3.1 million farmers operating 72.3 million hectares of farmland organically.

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