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Revolutionizing Agriculture: The Growth of Organic Farming in India

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ABSTRACT:

Objectives: This review aims to provide an overview of the present situation of organic agriculture in India and to suggest topics for further investigation. Methods/analysis: The review synthesizes existing literature and data on organic farming practices in India, drawing from historical accounts, agricultural policies, and research studies. It analyzes the evolution of organic farming practices in the country, the status of organic agriculture, and identifies key challenges and opportunities. Findings: Over decades, organic farming in India has evolved from traditional practices rooted in ancient wisdom to a modern agricultural system that emphasizes sustainability and environmental stewardship. The review highlights the historical context of organic farming in India, tracing its origins to ancient agricultural techniques documented in texts such as the Vedas. It also discusses the challenges faced by organic farmers in India, including issues related to soil health, pesticide toxicity, and the sustainability of agricultural production. Novelty/improvement: This review contributes to the existing literature by providing a comprehensive overview of the present state of organic agriculture in India. By identifying key challenges and opportunities, it offers insights for policymakers, researchers, and practitioners to further promote and advance organic farming practices in the country. Additionally, the review suggests areas for future research to address the evolving needs of the organic farming sector in India.

1. Introduction

The inception of the organic revolution in India can be traced back to Howard's pioneering work, whereby he formulated and envisioned several ideals and viewpoints that were later adopted by the people involved in this movement [1]. A purposeful reduction or elimination of the use of synthetic fertilizers, herbicides, growth promoters, and chemicals in animal feed is the goal of organic farming. Sustainability in the economy, society, and environment is one of the core tenets of organic farming [2]. Organic farming has gained significant global attention as a result of the increasing need for safe and nutritious food, as well as mounting apprehensions over contamination of the environment resulting from the uncontrolled use of agrochemicals. In India, a significant proportion of the population, namely 68%, relies on agriculture and its associated activities for their livelihood. Additionally, around 52% of the entire workforce in the country is engaged in this sector. According to reports, in order to achieve a factor of two GDP (gross domestic product) and around 4% agricultural growth in India, certain expenditures are deemed necessary [3]. The agricultural sector has significant importance in the Indian economy, given that India is the leading global provider of rice, wheat, and cotton. India is recognized as the second most prominent global exporter of sugar cane, vegetables, fruit, & tea [4], [5].

The effects of pesticides on the environment, ecology, and human health have drawn attention throughout the last ten years [6]. To maintain soil productivity, increase biodiversity, and manage pests, organic farming methods use biological fertilizers, dung, rotation of crops, and mechanical cultivation [7]. Towards the end of 2017, the percentage of organic farming worldwide had risen to 20% of all farmlands. Moreover, the percentage of cropland that is organic is rising across all continents. The global market for organic products has grown as well, reaching USD 97 billion [8]. Customers are accepting more organic goods because they think they are more nutritious and environmentally friendly [9-11].

Organic agriculture is an agricultural production approach that strictly prohibits the use of synthetic

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substances, including fertilizers, insecticides, and growth regulators. This agricultural approach prioritizes rotation of crops, the use of waste derived from crop leftovers and animals, and the implementation of mechanized systems of farming [12]. Organic agriculture can be defined as "an integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity while, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones [13-16].

Numerous conventional agricultural practices continue to be used and are seen as significant in contemporary times. Organic farming integrates traditional agricultural practices with contemporary scientific methods. Organic farming is a holistic approach to manage growth that promotes and enhances the conservation of agroecosystems, such as habitats, biological phases, and the functioning of soil ecosystems. The practice encompasses the use of techniques aimed at achieving optimal agricultural productivity while minimizing adverse impacts on both the environment and human communities. The primary emphasis is on the advancement of agricultural techniques, taking into account the utilization of external resources in farming. This is done in awareness of the fact that farming practices must be modified to satisfy the unique needs of a particular location or region. The objective is accomplished by using, if possible, agronomic, microbiological, and mechanical methodologies within the cultivation system, in contrast to traditional resources [17].

Organic farming is a kind of farming where synthetic herbicides, chemical fertilizers, regulators of growth, and additives for animal feed are purposefully used less or not at all throughout the production process. Figure 1 illustrates the fundamental principles of organic farming, which revolve on the pursuit of social, economic, and environmental sustainability [18]. [Figure 1].

Organic farming is a commonly used agricultural approach that is largely regarded as a superior option to mitigate the adverse consequences associated with chemical-intensive farming practices. Multiple definitions of organic agriculture exist, with the one provided by the United States Ministry of Agriculture (USDA) being widely regarded as the most comprehensive and rigorous. Organic agriculture refers to a meticulously developed and managed system that aims to generate agricultural goods while keeping the quality of organic food along the supply chain until it reaches the end customer [19]. The productivity of crops in organic farming relies on the interplay of inherent biological processes and the use of organic waste materials, including crop residues, animal manure, and farm byproducts. According to organic regulations, it is mandatory for organic lands to undergo a management period of three years prior to the first harvest of a certified organic crop, using organic practices. The period in when the ground and the management undergo adaptation to the new system is often referred to as the adjustment stage.

In Tamil Nadu and Uttarakhand, the yields of organic and conventional farming were generally equivalent. In Madhya Pradesh, however, organic farming had a lower yield since farmers concentrated on producing cash crops. The amount produced from combining food crops was often greater, even if the output from rice and wheat was typically lower under organic systems [20].

2. Organic Sources of Plant Nutrients

Currently, the prevailing estimations indicate that around 25-30 percent of the nutritional requirements for Indian agriculture may be fulfilled from diverse organic sources. The use of farmyard manure (FYM) as a means of supplementing the full nitrogen (N) need has been shown to maintain crop output at levels above those achieved via the use of traditional nitrogen fertilizers [21]. The incorporation of organic matter fosters the growth and productivity of fungus and other beneficial soil organisms. Additionally, it aids in mitigating the escalating occurrence of additional and micronutrient deficiencies, while also supporting elevated crop productivity and soil well-being [22].

The concentrations of nutrients in farmyard manure (FYM) often exhibit limited magnitudes and significant variations, contingent upon factors such as the origin of the manure, prevailing circumstances, and the period of storage. The nitrogen (N), phosphorus (P), and potassium (K) concentrations in fresh farmyard manure (FYM) exhibit significant variation, ranging 0.01-1.9 % on a dry mass basis. This variability may be attributed to the diverse characteristics of waste production and storage methods [23,24]. According to Tandon [25], the typical

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composition of well-rotted farmyard manure (FYM) includes 0.5% nitrogen (N), 0.2% phosphorus pentoxide (P2O5, and 0.5% potassium oxide (K2O). According to Gaur [26], the treatment of 25 t ha−1 of well-rotted farmyard manure has the potential to provide 56 kg P2O5, 112 kg N, and 112 kg K2O per hectare. Numerous researchers from across the globe have conducted studies demonstrating the diverse advantages associated with the use of farmyard manure (FYM) in terms of enhancing soil characteristics and increasing crop yield [27].

3. Impact of organic nutrients on the biological characteristics of soil

Compost comprises components from bacteria, actinomycetes, and fungi. Introducing fresh humic material not only fosters the growth and function of these microbes but also facilitates their integration into the compost, enhancing overall microbial activity and decomposition processes [28-30]. Additionally, compost was crucial in preventing plant nematodes and lessening the effects of pesticides by sorption. Pesticides attached to clay fragments or soil organic matter are less bioavailable and adaptable, but they are also less susceptible to microbial breakdown, making them more persistent [31-33]. By adding a significant amount of carbon to the soil, composting material boosted the number of heterotrophic fungi and bacteria as well as the production of soil enzymes that convert inaccessible nutrients into available forms. Production of soybeans (Glycine max L. Merr.) was increased by rhizobium infused FYM and PSB inoculation [34].

Singh and Bohra [35] discovered a rice-pea-black gram (Vigna mungo L.) cultivation system had a greater number of bacteria, actinomycetes, and fungus than the rice-wheat agricultural system. Vegetable crops often responded to Azotobacter inoculation better than other field crops did. In contrast, the quantity generated rise in the instances of wheat, maize, jowar (Sorghum bicolor L. Moench), cotton (Gossypium spp.), and mustard crop using Azotobacter chrooccocum culture was 0–31% higher than control [36].

Organic farming yields crops that are as productive as conventional farming in low-input agriculture. It was discovered that using rice straw compost in combination with Azotobacter and PSB were superior to using rice straw alone [37]. Growth-promoting chemicals generated by Azotobacter enhanced seed growth and germination with longer root systems. Additionally, it generated polysaccharides that enhanced soil agglomeration [38].

4. Types of Organic Framing

4.1 Pure organic farming

It includes employing biopesticides and organic manures while completely avoiding the use of inorganic chemicals and pesticides [39].

4.2 Integrated Organic Farming Systems

Pure organic farmers want not to utilize any technology at all in their daily operations. Integrated organic farming systems employ all available technology to increase food production and improve their quality of life. This is not the case with them. They do not, however, still include significant levels of chemicals, insecticides, or similar substances. remaining within organic guidelines.

5. Status of Organic Farming in India

Globally, organic farming is becoming more and more popular; in 2019, over 72.3 million acres of land were planted organically [41]. With the National Programme for Organic Production (NPO) established in 2001 under the Agricultural as well as Processed Food Products Export Development Authority (APEDA) of the Ministry of Commerce and Industry, only 85% of India's 14,000 tonnes of organic production in 2002 was exported. The National Mission for Sustainable Agriculture was established to support organic farming after the Indian government passed the nation's first organic farming policy later in 2005 [42,43].

6. Key features of Organic Farming

It uses natural bacteria as biological fertilizers for supplying crop nutrients [44,45].

- It preserves the quality of the soil by using organic waste.
- It aims to protect the environment and conserve wildlife.
- It replaces chemical weed and pest control with crop rotation, organic manures, and natural predators.
- The nitrogen content is maintained by legumes' assistance in nitrogen fixation [46-48].

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7. Components of Organic Farming

Rotation of crops, biologically fixing nitrogen, crop wastes, biological pesticides, and methane slurry are the most important components of organic farming. One important component of organic husbandry that effectively boosts soil fertility and promotes crop development in a sustainable manner is vermicomposting [49]. The following are the elements of organic farming:

- Crop Residue

India is a leader in the recycling nutrients during organic farming and has a huge potential for utilizing crop leftovers and cereal straw. Stems, stems, leaves, and seedpods are examples of these leftovers. Fungal investments made from crop leftovers improve soil physicochemical properties and crop yields [50].

- Crop Rotation

Crop rotation on the same land should be done twice or more to practice sustainable husbandry practices, which include controlling weeds, insects, and environmental factors. For instance, rotating legumes increase the fertility of the soil.

- Organic Manure

Organic manure that comes from living things, such as birds, plants, animals, and human waste. Organic manure, whether from a factory or a beast, is a well-spoiled substance devoid of chemicals, harmful organisms, and weed seeds. It is used in organic husbandry. Organic fertilizer directly supports crop growth by enhancing humic substance absorption, which raises soil productivity by expanding the availability of main & minor industrial nutrients through soil microorganisms [51].

- Wastes

A product or material that cannot be used as intended is referred to as garbage. Unlike garbage through natural ecosystems (e.g., oxygen, carbon dioxide, dead organic matter), waste from human activities is often very robust and decomposes slowly. There are two categories of trash: municipal and sewage waste and industrial garbage. Coir debris and other industrial byproducts like wasted marshland may be used as fertilizer. The two main types of organic waste are municipal and wastewater [52].

- Urine

The macronutrients N, P, and K needed to produce fertilizer are found in urine. Although it is not used enough and has a low value, fatal urine is a valuable toxin. Because it includes nutrients comparable to nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), and magnesium (Mg), the exercise of mortal urine is gaining attention as an essential poison [53].

- Bio fertilizers

In general, idle cells of effective strains of nitrogen-fixing, phosphate-solubilizing, or cellulite microorganisms are used as bio fertilizers or microbial inoculants for seed, soil, or composting areas. The idea is to add numbers of similar microorganisms and speed up specific microbial processes to compound the extent of the vacuity of nutrients in a form that can be assimilated by factory workers.

- Vermi Compost

Earthworms are used in the vermicomposting process, which turns organic waste into a guck-like substance called vermicompost [54]. "Worm-husbandry" is what vermiculture is. Earthworms produce vertices, which are rich in nitrates and minerals including phosphorus, magnesium, calcium, and potassium, after feeding on organic waste accessories. When compared to control plots, vermicompost primarily enhanced the concentrations of soil total organic carbon, total N, P, K, Ca, Zn, and Mn, all of which may support plant development.

- Bio-pesticide

Fungicides known as "bio-pesticides" are derived from natural elements such as animals, plants, microorganisms, and certain minerals [55]. These substances have an impact on the physiology and behaviour of nematodes, fungi, and insects. Bio-pesticides come from factories and contain things like certain secondary compounds, phenolics, and alkaloids.

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8. Methods of Organic Farming

8.1. Soil Management

The basis of life on Earth is soil. To preserve and safeguard the soil resources, certain soil management techniques are required [56-62]. Crop rotation is the practice of planting a variety of crops in a given region year after year. Growing the same crop in the same spot every season will deplete the soil of that nutrient; but, if we rotate our crop rotation every season, the soil's nutritional balance will be preserved [63-65]. Crop rotation thus aids in preserving the quality of the soil. Because rhizobia bacteria enable legume plants to fix atmospheric nitrogen, they are also employed to boost soil fertility. Manure includes nutrients like nitrogen, therefore adding it also improves the condition of the soil [66-68].

8.2. Weed management

Unwanted plants that provide competition to agricultural plants are known as weeds. There are many methods in which organic farming supports weed control [69-72]. The technique called mulching involves using plastic sheets to prevent weed growth. Weeds' top growth is removed by mowing and trimming. Grazing is another technique that inhibits the development of weeds. Additionally, weed reduction is promoted by organic crop rotation [73,74].

8.3. Crop diversity

The custom of cultivating only one kind of crop was observed in the past. Table 1 illustrates the major crops exported from India. However, polyculture—the technique of cultivating many crops in one location—is becoming more and more popular these days [75-79]. Through its support of beneficial soil microbes, it enhances the quality of the soil. [Table 1].

9. Challenges During Adaptation of Organic Farming

Although organic farming techniques have great potential to increase farm resilience, current trends indicate that organic farms could no longer be a homogenous group due to the presence of two distinct strategies [80-83]. On the one hand, there are farms that manufacture a range of goods while still generating income from specialized markets. These farms sell their goods directly to consumers, depending on their good name to guarantee the integrity of the goods. Conversely, an increasing number of specialty farms are depending on certification and regulated production techniques. They often concentrate on certain crops, sell their goods via retail chains, and target both the larger domestic and global markets. It is unclear if the second set of organic farms still exhibits the traits of agricultural resilience since they downplay some aspects of the industrialized food chain. The introduction of regulatory regulations for organic agriculture and the influence of market dynamics seemed to be the main causes of this contradiction in organic farms [84].

10. Need & Emerging issue of Organic Farming in India

In addition to serving as a source of nutrients, organic manures can boost the soil's biodiversity and microbial population activity, affect the structure of nutrient turnover, and have a variety of additional physiological, chemical, and biological effects [85]. Since the negative effects of conventional agricultural techniques on the environment and public health have come to light, there has been a growing demand for organic farming. By using less water and causing less contamination to groundwater, organic farming contributes to the conservation of water resources. Because it promotes the growth of a variety of crops and the safeguarding of natural environments, it also fosters biodiversity. Because organic farming builds resilience within the agroecosystem, it makes the system more resilient to the negative impacts of climate change. It develops effective, ecologically friendly agricultural techniques that prevent soil erosion and are resistant to changes in temperature and drought.

Additionally, conservation efforts, restoration projects, and sustainable and ecologically friendly management are encouraged by organic farming. Compared to contemporary agriculture, organic farming has less financial requirements. Additionally, organic farming aids in communities' and farmers' adaptation to the unpredictable effects of climate change. Furthermore, organic farming satisfies several prerequisites found in effective adaptation tactics [86,87]. Most challenges in modern food production and agriculture may be resolved by practicing organic farming. The foundations upon which organic agriculture is built are the values of environment, justice, health, and caring. Nutrient-rich

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and mostly devoid of chemicals and pesticide residues, organic food is also healthier. Organic farmers are conscious of the health benefits of eschewing artificial pesticides and fertilizers that are often employed in agriculture [88,89].

In the agricultural industry, marketing is essential to the expansion of both the industry and farmers. This helps farmers get a fair price at every step of the process, from storing food to selling goods in the market. There is presently a minimal market for organic farmers since only the wealthiest members of society can afford organic goods. According to reports, a major problem was a shortage of storage, which was followed by poor customer demand, a lack of awareness about premium pricing, expensive transportation, fluctuations in agricultural prices, and a lack of government assistance [90].

Since these elements are crucial to marketing channels, government assistance is also required. For example, the absence of government backing for marketing made organic farming unfeasible for the farmers in Haryana as a means of subsistence [91]. Delivering organic goods calls for a certain skill set since the market for them differs greatly from the usual market [92].

11. Growth of region under organic farming

Table 2 indicates the growth of area percentage share of total agricultural land and produces in the year 2011 to 2021. In under area of organic farming in 2011 was 124.75 mha and 2021 has increased 129.34 mha of organic area (farmland). [Table 2].

12. Benefits of Organic Farming

12.1. Product Quality

When addressing various physiological procedures and results in crop plants, such as appearance, taste, appearance, nutrition and safety qualities, and texture that impact the value to the customer and environment, crop product quality is an essential factor to take into account. As many customers have predicted, recent research demonstrates that vermicomposting is associated with higher product quality throughout process modifications, better durability and storage for a final product, and improved physiological features for a product. When plants develop properly, they reach their full potential and provide components that are necessary to produce goods that are good for the environment and customers. Biofertilizers are essential in comparison studies because they facilitate the breakdown of complex nutrients, giving plants easy access to the nutrients they need for the best possible development and growth of their products [93]. Furthermore, Kanthesh [94] emphasizes that biofertilizers inhibit microorganisms that may degrade product quality, guaranteeing that the latter is secure and fit for ingestion and re-cultivation.

12.2. Crop Productivity

Vermicomposting and biofertilizers have received special attention in the many studies that have examined the impact of organic farming on crop yield.

Cidón asserts that vermicomposting has a good correlation with agricultural productivity and revenue. The advantages of vermicomposting, which reduces nitrogen concentration, result in enhanced and stable output, increased revenue for farmers, and decreased expenses associated with buying and applying nitrogen fertilizers [95].

12.3. Environmental Sustainability

Organic farming plays a pivotal role in promoting environmental sustainability through its commitment to ecologically sound practices. By eschewing synthetic pesticides and fertilizers, organic agriculture minimizes chemical runoff, protecting water sources and mitigating soil and water pollution. The emphasis on crop rotation, cover cropping, and reduced tillage practices enhances soil health, fostering biodiversity and promoting natural nutrient cycling. The cultivation of diverse crops in organic systems provides habitats for a variety of species, contributing to higher levels of biodiversity. Additionally, organic farming methods, such as agroforestry and polyculture, not only enhance ecological resilience but also help in water conservation by improving soil structure and reducing water runoff [96].

12.4. Soil Health

Organic farming stands out as a beacon for the improvement of soil health, embracing practices that foster long-term sustainability. Central to this approach is the rejection of synthetic pesticides and fertilizers, reducing the risk of soil contamination and degradation. Organic farmers prioritize the use of organic matter,

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cover crops, and compost, enriching the soil with essential nutrients and enhancing its structure. Through the implementation of crop rotation, organic farming mitigates soil erosion, promotes water retention, and breaks cycles of pests and diseases, contributing to overall soil resilience. The encouragement of beneficial microorganisms and earthworms in organic systems further facilitates nutrient availability and efficient soil processes [97].

12.5. Biodiversity Conservation

Organic farming emerges as a champion in the realm of biodiversity conservation, embodying principles that prioritize ecological balance and resilience. The rejection of synthetic pesticides and fertilizers in organic practices fosters an environment conducive to diverse flora and fauna. Crop diversity, a cornerstone of organic farming, provides varied habitats and food sources, encouraging a rich array of plant and animal species. The use of cover crops and agroforestry further enhances biodiversity by creating microenvironments that support different organisms. By emphasizing beneficial bugs and companion plants as natural pest control strategies, organic farming fosters a healthy environment where predatory animals deter potential pests [98].

12.6. Reduced Pesticides Residues

Crop rotation, natural alternatives, and other preventative measures are the mainstays of organic agriculture, which aims to reduce or completely do away with synthetic pesticides. Numerous studies have shown that this careful technique considerably reduces the occurrence of pesticide residues in crops. For example, a meta-analysis conducted in 2012 by Smith-Spangler et al. showed that organic food typically had less pesticide residue than its conventionally produced equivalents. Because organic farming minimizes the possibility of chemical runoff and contamination, it protects ecosystems and water sources in addition to protecting consumer health by eliminating the use of synthetic pesticides [99].

12.7. Nutritional Quality

According to the research, the quantities of many advantageous substances, such as antioxidants, vitamin C, and polyphenols, were much greater in organic crops. Organic food is said to have a higher nutritional value because of things like better soils, less synthetic fertilizer usage, and less synthetic pesticide use. Furthermore, organic farming's focus on biodiversity and soil quality may help plants absorb nutrients more effectively. The availability of vital nutrients for plant development may be improved by the use of organic additions like compost and the presence of helpful microbes [100].

13. Conclusion

Organic farming addresses the pressing issues of food security, the environment, conserving water, soil erosion, & climate change. It is a sustainable and environmentally conscientious agricultural practise. Organic farming provides a comprehensive response to the problems facing our global food system by enhancing soil health, getting rid of dangerous chemicals, maintaining biodiversity, saving water, and sequestering carbon. Its methods guarantee that we can keep our planet's ecosystems healthy while supplying food that is both wholesome and safe for both the current and next generations. Adopting organic farming is not only a decision to make; it is a must for building a more resilient and environmentally friendly agriculture future. In order to guarantee a happier and more environmentally friendly world, it is essential to promote and support organic agricultural methods as more people, communities, and countries become aware of these advantage.

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