International Journal of Environment and Climate Change

Volume 13, Issue 9, Page 2142-2151, 2023; Article no.IJECC.104132
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Benefits and Challenges of Indian Organic Farming: A Comprehensive Review

Nirjharnee Nandeha [a], Ayushi Trivedi [b*], Neelendra Singh Verma [c], Neha Kushwaha [d] and Satish Kumar Singh [d]

[a] Directorate of Research Services, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India.
[b] BM College of Agriculture, RVSKVV, Khandwa (M.P), India.
[c] State Forest Research Institute, Jabalpur, (M.P), India.
[d] Central Institute of Agriculture Engineering, Bhopal, (M.P), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i92694

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/104132

Review Article

Received: 23/05/2023
Accepted: 25/07/2023
Published: 26/07/2023

ABSTRACT

The organic movement may suddenly be in the mainstream's spotlight, but that hasn't always been the case. Local organic farmers have developed, experimented with, and exchanged production techniques since the 1950s. Globally, the production of organic crops in the organic farming system is increasing momentum. It is necessary to develop a variety of alternatives to chemical-intensive agriculture in order to achieve sustainable food, livelihood, and environmental security. With 72.3 million acres of land, organic farming is practiced in 187 countries worldwide. From 0.58 thousand ha in 2003–2004 to 26.6 thousand ha in 2020–21, the area used for organic farming rose quickly, and numerous government programs are being launched. The importance of health advantages is

**Corresponding author: E-mail: ayushikhandwa@gmail.com;*

growing as more individuals become aware of the food they and their family members eat. As a result, products created by organic farming exist to some extent. In the past, individuals spent money on premium local produce, meat, and organic goods. This resulted in a long life and a stable way of life. Therefore, organic farming supports the one health approach to ensure the health of the environment, plants, animals, people, and soil. Organic farming uses a regenerative method to rebuild food and agricultural systems, which enhances ecosystem benefits. As a result, it offers a realistic alternative for producing clean, sustainable food with little harm to the environment. Small and marginal farmers should use organic agricultural methods, particularly for their long-term food security and to reduce risk. Long-term organic farming adoption in horticulture crops will benefit from sustained efforts from research institutions, developmental organizations, progressive farmers, input dealers, processors, and other stakeholders. This article focuses on appropriate organic farming techniques for horticultural and agricultural crops that are location-specific. This paper gives a general summary of organic farming's advantages, difficulties, and current situation in India.

Keywords: Climate change; biomass; biodiversity; soil health; organic products; organic farming.

1. INTRODUCTION

The main goal of agricultural development policies for developing nations should be to increase land productivity through lower costs, improved product efficiency, and minimal or no harm to both people and the environment. In 2020, Nedumaran et al. The transition of rural agriculture to well-sustainable agriculture may be facilitated by organic farming, which can serve as a foundation for sustainable agriculture, cover conversion costs, and preserve the sustainability of soil. The success of the Green Revolution was based on the employment of high-yielding varieties (HYVs), chemical fertilizers, pesticides, and agricultural mechanisation, all of which put an unprecedented strain on our natural resource base, including conventional methods of disease and pest control. Wheat (*Oryza sativa* L.) and rice (*Triticum aestivum* L.) production has increased as a result of the Green Revolution, but at the expense of other crops (particularly coarse cereals and pulses) and the overuse of fertile soils and precious water resources. On the one hand, the high dose application of fertilizers reduced the soil's physical, chemical, and biological qualities, while on the other, it increased soil salinity and contaminated groundwater resources. Pesticide use has caused significant environmental and health consequences. The decline in soil health is a crucial factor in the annual decline in crop output and the growth rate of total factor productivity [1-4]. The majority of the districts' soils are deficient in N (228 districts), P (170 districts), and K (47 districts), although 326 districts receive more than 100 kg of nutrients (N, P, and K)/ha (FAI, 2014). An excessive amount of soil nutrients are mined as a result of exhaustive cropping practices. Around 800 kg/haare removed by the rice-wheat-cowpea fodder system [12-15]. The problem is additionally exacerbated by a bigger nutrient application gap between recommended and farmers' practices. According to the World of Organic Agriculture 2018 study, India is home to 30% of the world's organic producers, yet it only makes up 2.59 percent (1.5 million hectares) of the 57.8 million hectares of total organic agricultural space. Pandey and Sengupta (2018) (The farming community as a whole has limited resources, making it difficult for them to purchase fertilizers and chemicals in sufficient numbers, which promotes organic farming. Additionally, organic farming is advantageous for small-scale and dispersed agricultural landowners Singh, [46].

The cultivation of organic crops, according to Mendon et al. (2020), is a special practise that balances environmental sustainability and also controls the negative impact both on customer safety by instilling a favourable notion in the minds of the customers. According to Varkey (2020), both emerging and developed nations are prioritising the environmental sustainability of agricultural production, methodologies, and practices. Due to a variety of reasons, farmers' traditional knowledge of indigenous agrarian practices is being questioned more and more frequently. Magnaye's [47] research investigates the connection between smallholder organic farming and entrepreneurship while taking into account both the entrepreneurship's economic advancement capabilities and organic farming's approach to environmental conservation. In addition, it aims to ascertain, through qualitative analysis using case studies, how smallholder organic farming can be planned and the competencies needed by an organic farmer when venturing into an organic farm enterprise.

Magnaye, [47] examines the relationship between smallholder organic farming and entrepreneurship taking into account the environmental conservation approach of organic farming and the economic enhancement features of entrepreneurship. However, Giovannucci [48] claims that there is substantial evidence that organic farming practices may benefit small farmers in general [28-32]. In fact, the majority of the cases made evident that there were a lot of direct benefits and associated externalities, leading one to the logical conclusion that encouraging organic farming practices among small and resource-poor farmers can be justified. The most significant problem India has faced since gaining independence, according to Yadav et al. [50], has been producing enough food to feed the country's expanding population. As a result, irrigation water and fertilizers are infused with high-yielding cultivars.

2. NATURAL OR ORGANIC FARMING

Lord Northbound first used the term "organic farming" in 1940. The organic movement had its start at the turn of the nineteenth century. Justus Von Liebig created a mineral plant nutrition theory in 1840. Liebig thought that some mineral salts may directly replace manure., 2020 Filipovich.

3. INDIAN ORGANIC FARMING

Increasing agricultural production and stabilizing it in a profitable and practicable way has become important due to the ever-increasing population in contrast to the ever-decreasing quantity of life resources like food and water. The Dr. MS Swaminathan-credited "Green Revolution" has now reached a peak, and as a result of declining returns, it is now necessary to develop alternative methods. Additionally, an issue known as "pollution" has resulted from the excessive use of fertilizers and synthetic growth regulators. A natural balance between life and property is necessary for existence today. Given that fossil fuels are non-renewable and on the verge of extinction, organic, environmentally friendly methods of farming and agriculture have gained popularity [16-17].

Given that fossil fuels are non-renewable and on the verge of extinction, organic, environmentally friendly methods of farming and agriculture have become more and more important. (https://www.farmingindia.in/organic-farming/)
About 2.75 million MT (2019–20) of certified organic products were produced in India, including all types of food products such as oil seeds, sugar cane, cereals and millets, cotton, pulses, aromatic and medicinal plants, tea, coffee, fruits, spices, dry fruits, vegetables, processed foods, and others. Producing organic cotton fiber, functional foods, and other items is also done in addition to the edible industry. Madhya Pradesh is the main producer among the several states, followed by Maharashtra, Karnataka, Uttar Pradesh, and Rajasthan. Regarding commodities The largest group is oil seeds, followed by sugar crops, cereals and millets, tea and coffee, fiber crops, fodder, pulses, medicinal/herbal and aromatic plants, spices, and condiments. 6.389 lakh MT were exported in total from 2019 to 20 [23-27]. The export of organic food brought in about INR 4,686 crore (689 million USD). Exports of organic goods go to the United States, the European Union, Canada, Switzerland, Australia, Japan, Israel, the United Arab Emirates, New Zealand, Vietnam, etc. Processed foods, including soy meal, take the lead among products in terms of export value realization, followed by oilseeds (13.25%), plantation crop products like tea and coffee(9.61%), cereals and millets(8.19%), spices and condiments(5.20%), dry fruits(4.98%), sugar(3.91), medicinal plants(3.84%), and others [33-39].

4. FOOD CONTAMINATION AND A DROP IN NUTRITIONAL VALUE

Pests develop genetic mutations and chemical resistance as a result of the widespread application of chemicals. Only 0.1% of pesticides, according to Pimentel [51], actually reach the intended pests; the remainder is applied to unintended areas. The total amount of pesticides consumed in the nation during 2012–2013 decreased significantly (by about 15%) when compared to earlier years. The development of integrated pest management (IPM) technology, such as bio-control, and the execution of government awareness campaigns may be to blame for the decline in consumption. However, pesticide residue is a significant issue. In general, cotton (37%) and fruits (grapes, 2%), as well as vegetables (13%), receive the most pesticide application in the transition to organic farming. The expansion of the area has been facilitated by favourable policies, technological developments, demonstrations, and farmer-led inventions. India produces a vast variety of crops under organic management, with cereals, millets, pulses, sugarcane, oilseeds, and fibre crops

Fig. 1. Organic Farming Concept

making up the majority of the basket. By March 2026, the Indian government hopes to have at least 4% of its net cultivated land converted to organic farming. However, the promotion of organic farming is restricted by restrictions on production, the accessibility of inputs for nutrient, weeds, insect, and disease management, among other concerns. In terms of the overall amount of arable land used for organic farming and the number of organic producers worldwide, India is now ranked ninth. India exports 0.6389 million tonnes of certified organic products worth 46,860 million (689 million USD) in 2019–20, or around 2.75 million tonnes total. In order to promote organic agricultural practices in India, the ICAR launched the All India Network Programme on Organic agricultural (AI NPOF). The 'Towards Organic' (integrated crop management) approach for input-intensive areas (food hubs) and the 'Certified Organic' approach integrating tradition, innovation, and science in the 'de-facto organic' areas (hill and rainfed/dryland regions) are better options for national food security, higher household income, and climate resilience [49]. These approaches will further improve the safe food production and meet social values [18-22].

5. CONCEPT, SUMMARY OF ORGANIC AGRICULTURE'S HISTORY, AND ITS STRATEGIC IMPORTANCE

Agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity, are promoted and enhanced through organic farming, a comprehensive production/management approach. It emphasises the use of management practices above the use of off- and on-farm inputs while taking into account the need for regionally adapted systems according to regional conditions. Instead of employing synthetic materials to carry out any particular function within the system, this is performed by using, if possible, agronomic, biological, and mechanical means [20]. According to the IFOAM, "Organic agriculture is a production system that maintains the health of soils, ecosystems, and people. Instead of using inputs with negative impacts, it relies on biological processes, biodiversity, and cycles that are tailored to local conditions. Organic farming blends science, creativity, and tradition to benefit the environment as a whole, foster just relationships, and improve everyone's quality of life [5-11].

Crop rotations, crop residues, animal manures, legumes, green manures, safe off-farm organic wastes, and biological pest control techniques are all used in organic farming systems to maintain soil productivity and tilth, feed plant nutrients, and control insects, weeds, and other pests. Organic farming can be defined in its most basic terms as "a type of diversified agriculture where crops and livestock are managed through use of integrated technologies with preference to depend on resources available either at the farm or locally." The biggest advantages of organic agriculture, according to Auerbach et al. (2013), are its reliance on locally accessible, fossil fuel independent resources that experience little agro-ecological pressures and are cost-effective. She refers to organic farming as a "neo-traditional food system," which integrates both

contemporary science and traditional knowledge. According to records on paddy grain yield under traditional farming methods, the Lalgudi Sivagnanam Co-operative Agricultural Society in the Madras Presidency recorded yields up to 2.95 t/ha in the first crop (Kuruvai) and 2.81 t/ha in the second crop (Thaladi) [1925-26] [Royal Commission on Agriculture in India report volume III, 1927]. Similarly, West Bengal reported a yield of 2.41 t/ha of wheat between 1970 and 1971 [Report of the National Commission on Agriculture].

6. RESEARCH INTO ORGANIC AGRICULTURE AND TECHNOLOGIES FOR FIELD CROPS

Numerous approaches to nutrient, pest, and weed management have been put to the test in multiple locations as part of the All India Network Programme on Organic Farming, leading to the development of technology for organic farming. The best cultivars for basmati rice, coarse rice, wheat, maize, chickpeas, groundnuts, mustard, soybeans, tomatoes, cauliflower, okra, French beans, turmeric, black pepper, and cotton have been identified. When grown using an organic production technique, these types typically produce a better yield.

7. METHODS OF NUTRIENT MANAGEMENT IN ORGANIC AGRICULTURE

7.1 Provision of Enough Nutrients from Organic Sources

In India, there is ample room for the production of enough organic inputs. Livestock makes up the largest portion of the various nutrient sources (almost 40%), followed by crop residues (30%) and other sources (15%), such as rural compost, vermi-compost, and agricultural wastes. The implementation of rotational manuring in cropping systems, integrated organic farming methods, and a combination of sources can all help address the problem of a sufficient supply of nutrients under an organic agricultural system.

7.2 Combination of Organic Sources of Nutrition

It has been discovered that combining many organic sources to provide nutrients to crops is very effective because it is impossible to meet nutrient requirements from a single source. For instance, a rice-wheat system needs about 30T FYM per year to satisfy its nutrient requirements. By implementing techniques for cropping systems involving green manures, legumes, and combined application of FYM + vermicompost + neem cake, this can be very readily controlled. The inclusion of neem cake into the soil has been shown to be overly successful, and this sort of management also aids in lowering the incidences of insects and diseases. To address the nutrient needs of crops, some combinations can be employed, including FYM (partially composed dung, urine, bedding, and straw), edible and non-edible oil cakes, enriched composts, and efficient microbes.

The goal of nutrient management in organic systems is to minimise losses and maximise the use of farm resources [53]. Giving back to nature what has been taken from it is part of the "feed the soil, not the plants" guiding principle [54]. Plants utilise organically derived nutrients through mineralization, which is mediated by soil microbes. These organisms play a crucial role in the mobilisation of nutrients in the soil and significantly contribute to the maintenance of a healthy soil system and, as a result, healthy plants (Veeresh, 1990). One of the most significant yield-limiting elements in the cultivation of organic crops is nitrogen (N) supply [55]. According to Berry et al. [56] and Ansari et al. (2002), the main source of nitrogen in organic agricultural systems is organic soil nitrogen that is indirectly supplied by inputs through legume intercropping in crop rotations or by recycling N through solid or liquid manure. Leguminous green-manure crops increase soil health, stop nutrient leaching, fix atmospheric nitrogen in the soil in the accessible form, and use surplus soil moisture (Ansari et al., 2021).

7.3 Management of Weeds in Organic Farming

Weeds are a significant issue in organic management, and nearly 43% of organic growers agreed that it was important to identify low-cost and free weed control methods in order to successfully practise organic farming. Between the plants, slash weeding needs to be done. You can remove the weeds from around the plant bases and use them as mulch. The weeded materials ought to be used as mulch directly on the ground. The additional options for managing weeds under organic management include stale seedbeds, manual weeding, and mechanical weeding. Effective crop rotation, diversified farming, and intercropping are also crucial for weed control.

7.4 Advancements in Organic Farming

Organic farming entails a variety of operations on the farm, from crop husbandry to livestock management to horticulture. Several programmes have been developed and put into place in India recently to encourage organic farming, which has led to a significant rise in both area and export over time, but there are still a lot of challenges to overcome. The key recommendations for increasing organic farming in the nation are as follows [40-45:

- The growth of organic farming is constrained by a number of factors, including a decline in yield during the first years of conversion, a lack of organic manures on the farm to meet nutrient demands, a mismatch between crop demand and soil supply caused by the slow release of nutrients from organic manures, difficulty handling the bulky manures, and insufficient certification Therefore, developing a comprehensive approach to handle each of these concerns is crucial.
- Lack of a consistent and dependable supply of certified inputs (such as seeds, bio-agents, bio-fertilizers, and manures) and an economically viable market for organic farm products is the main issue facing organic growers. In order to construct stable and trustworthy input-output chains in future organic clusters. The establishment of organic input production facilities in the public and private sectors as part of the nation's numerous development programmes calls for the connection of these facilities with appropriate marketing channels in order to maximise their capacity utilisation and ensure their viability. The development of certified organic input-marketing channels is urgently required for the country's expansion of organic farming.
- Potential organic agriculture zones need to be identified along the lines of "Special Economic Zones" and named as "Special Organic Agriculture Systems Zones" in order to capitalise on high-end domestic and worldwide export markets. Examples include the possibility of establishing "Organic Spice" zones in Kerala, "Organic Coconut Zones" in the Andaman and Nicobar Islands' Nicobar district, "Organic Basmati Rice Zones" in Uttarakhand, Western Uttar Pradesh, Haryana, and Punjab, "Organic Cotton Zones" in Madhya Pradesh, Gujarat, and Maharashtra, and "Organic Seed-Spice Zones" in Rajasthan and Gujarat. Similar to this, several specialised organic zones may be found inside the well-established horticultural belts in several states for the production and selling of various fruits and vegetables. For the purpose of luring visitors that value nature, these zones can also be developed into Agro-ecotourism hubs. Private investors who make investments in setting up organic input production, processing, and packing plants within the zone may be eligible for tax holidays. The zone should be designed so that all input, certification, processing, and packing needs are satisfied inside the zone.
- Crop + animal farming systems are widely used in India, which is a strength for the country's organic industry. This is a fantastic opportunity to set up integrated organic farming systems across all of the niches, which can then be used as a research and demonstration unit. Depending on the niche, clusters of villages need to be supported for organic farming systems.
- Adoption of the organic farming package and its promotion for specific crops should cease, and a system approach should be used instead. Providing the necessary nutrients and other inputs through crop and farming systems has proven to be effective. Each district of the states that have been recognised and/or are potential states should construct a "Model Organic Farm" in the agricultural system mode for marginal and small farmers.
- To ensure secure food security throughout the nation, the "Towards Organic" strategy should be used rather than switching over completely from inorganic to organic in the high-intensive agricultural areas. This strategy will help to boost the use efficiency of fertilizers and water while reducing the immediate heavy production losses during the conversion period. To achieve the intended results, government programmes for Integrated Nutrient Management, Plant Protection, and Water Management must be combined.
- The national standards for organic production are equivalent to those in the European Union and other significant nations. It is advantageous for export.

However, the domestic norm for organic production and certification, which also adheres to export criteria, needs to be reconsidered. As "safe food for all" is feasible through a "move towards organic," which incorporates integrated crop-management techniques. The domestic standard may take into account the integrated approach to production practices with the mandated maximum use of nutrients (up to 50%) in the form of chemical fertilizers. However, the methods used to manage weeds and pests should adhere to export standards. The notion that plants take nutrients in the form of inorganic substances regardless of the source, including organic, supports this statement as well.

- "Certified organic farming" in de facto organic zones (hills) and rainfed/dryland regions with a blend of tradition, innovation, and science will provide for Future income growth for farm households will also increase their climate resilience and ensure safe food security. System fitness. So, speciality crops and localities should promote organic cultivation.
- The cultivation, processing, and marketing of organic produce in the nation should be handled through Farmer Producer Organisations (FPOs). In actuality, connecting with a guaranteed market will be crucial for organic promotion. The Anand pattern, which was successful in the dairy industry, should be investigated for the spread of organic farming in the nation.
- In order to assure better profitability for organic growers, the minimum support price for organic produce should also be higher. By accounting for environmental services provided by the system, this can be achieved. Support for organic seed production should focus on the seed-producing chains of arable crops and green manures, specifically dhaincha (Sesbania bispinosa (Jacq.) W. Wight and sunhemp (Crotalaria juncea L.).
- To maintain the quality of organic produce and inputs, the establishment of sufficient and accessible laboratories for testing items primarily for pesticide residues is vital.
- India's north-eastern region has excellent potential for organic farming, especially in the hills where the usage of fertilizers, chemicals, etc. is minimal. Particularly for input production and output storage, branding and marketing, they should be given preference and infrastructure assistance. To store organic goods and provide sufficient benefit to the farmers, at least one cold storage facility or godown should be taken into consideration for each hub or cluster.
- The South Asia Association for Regional Cooperation (SAARC) nations must network their academic, research, market, certifying, and non-governmental organisations (NGOs) in order to share technology and reap the rewards of complementarily. In the SAARC countries, a real web-enabled information system is crucial for an organic agriculture system.

8. CONCLUSION

Since crops and animals are traditionally raised together in India, organic farming methods are still used today in more than 85% of farm households. India uses 128.3 kg/ha of fertiliser and 0.31 kg/ha of artificial insecticide on average, with many states using less of these synthetic inputs than the country as a whole. Despite technical advances, the efficiency of nutrient usage is still below average (33% for N, 15% for P, 20% for K, and 5% for micronutrients). In 2025, it is predicted that a variety of organic resources with a combined nutritional potential of 32.41 m t will be usable. It would be appropriate to adopt integrated crop management in the states that make up a significant portion of the world's food supply because it has been discovered that inter/mixed cropping (also referred to as "towards organic") increases the use efficiency of all expensive inputs, particularly fertilizers and water. In hilly and rainfed places, one could think of growing specialty crops organically (crops that yield more under organic conditions and have a market). Additionally, it will contribute to a rise in the nation's overall food production. To further improve the yields, organic farming technologies must be updated and improved. For organic farming to flourish in the nation, farmer-friendly certification policies and demand-driven supply chain management are crucial. The "towards organic" (integrated crop management) approach for intensive agricultural areas (food hubs) and "certified organic farming" with a combination of tradition, innovation, and science in the de-facto organic areas (hills) and rainfed/dryland regions will contribute to safe food security in the future in addition to raising the income of farm households and enhancing climate resilience.

The health of people, animals, and the environment will all benefit from this strategy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. A B Academic Press, UK. Koul O. Suresh, Walia, Dhaliwal, GS. Essential oils as green pesticides: potential and constraints. Biopesticide International. 2008;4(1):63–84.
2. Ansari MA, Saha S, Das A, Lal R, Das B, Choudhury BU, Roy SS, Sharma SK, Singh IM, Meitei CB, Changloi KL, Singh LS, Singh NA, Saraswat PK, Ramakrishna Y, Singh D, Hazarika S, Punitha P, Sandhu SK, Prakash N. Energy and carbon budgeting of traditional land use change with groundnut– based cropping system for environmental quality, resilient soil health and farmers income in eastern Indian Himalayas. Journal of Environment Management. 2021;293:112892. Available:https://doi.org/10.1016/j.jenvman.2021.
3. APEDA. Agricultural and Processed Food Product Export Development Authority; 2021. https://apeda.gov.in/apedawebsite/organic/organicproducts.htm.
4. Askegaard M, Olesen JE, Rasmussen IA, Kristensen K. Nitrate leaching from organic arable crop rotations is mostly determined by autumn field management. Agriculture, Ecosystems and Environment. 2011;142:149–160. Available: https://doi.org/10.1016/j.agee.2011.04.014.
5. Auerbach R, Rundgren G, Scialabba NH. Organic agriculture: African experiences in resilience and sustainability. Natural Resources Management and Environment Department Food and Agriculture Organization of the United Nations, Rome; 2013. ISBN 978–92–5–107666–8 (print), E–ISBN 978–92–5–107667–5 (PDF).
6. Aulakh CS, Ravisankar N. Organic farming in Indian context: a perspective. Agricultural Research Journal. 2017; 54(2):149–164. DOI No. 10.5958/2395–146X.2017.00031.X.
7. Berry PM, Sylvester–Bradley, Philipps R, Hatch L, Cuttle DJ, Rayns SP, FW, Gosling P. Is the productivity of organic farms restricted by the supply of available nitrogen? Soil Use and Management. 2002;18:248–55.
8. Bhattacharyya P, Chakraborty G. Current status of organic farming in India and other countries. Indian Journal of Fertilizer. 2005;1(9):111–23.
9. Carpenter–Boggs L, Reganold JP, Kennedy AC. Biodynamic preparations: short term effect on crops, soils, and weed populations. American Journal of Alternative Agriculture. 2000;15:110–18.
10. Charyulu K, Biswas S. Organic Input Production and Marketing in India – Efficiency, Issues and Policies. CMA Publication No – 239; 2010.
11. Crowder DW, Reganold JP. Financial competitiveness of organic agriculture on a global scale. Proceedings of the National Academy of Sciences. 2015;112(24):7,611–16.
12. Dahama AK. Use of traditional and nontraditional additives for organic farming. (In) Organic Farming for Sustainable Agriculture. Agrobios (India), Jodhpur, Rajasthan. 2003;91–227.
13. Das K, Medhi DN, Guha B. Application of crop residues in combination with chemical fertilizers for sustainable productivity in rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system. Indian Journal of Agronomy. 2003;48: 8–11.
14. David C, Abecassis J, Carcea M, Celette F, Friedel JK, Hellou G, Hiltbrunner J, Messmer M, Narducci V, Peigné J, Samson MF, Schweinzer A, Thomsen IK, Thommen A. Organic bread wheat production and market in Europe. Lichtfouse, E. (Ed.), Sustainable Agriculture Reviews, 11, Springer, Dordrecht, Heidelberg, New York. 2012;43–62.
15. De Ponti T, Rijk B, van Ittersum MK. The crop yield Special issue 2021] ORGANIC FARMING RESEARCH IN INDIA S161 gap between organic and conventional agriculture. Agricultural Systems. 2012;108: 1–9.
16. DES. Directorate of Economics and Statistics, Department of Agriculture Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare; 2020.
17. DES. Directorate of Economics and Statistics, Department of Agriculture

Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare. Third Advance Estimates of Production of Food grains; 2021.
Available: https://eands.dacnet.nic.in/ Advance_Estimate/.pdf.

18. Elamathi E, Cholan JRR, Vijayakumar N, Ramamourti A. Formulation and optimization of various nuclear polyhedrosis virus isolates and assessment of their insecticidal activity *against Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) larvae. Archives of Phytopathology and Plant Protection. 2012;45(7):750–65.
19. Erisman JW, Sutton MA, Galloway J, Klimont Z, Winiwarter W. How a century of ammonia synthesis changed the world. Nature Geoscience. 2008;1:636–39.
FAI. 2014. 59th Annual Report, Fertilizer Association of India, New Delhi. 2013–14.
20. FAO. Food and Agriculture Organization; 1999.
Available: http://fao.org/ organicag/oa-bag/oa-bagi/en.
21. Gao C, El–Sawah AM, Ismail Ali DF, Hamoud YA, Shaghaleh H, Sheteiwy MS. The integration of bio and organic fertilizers improve plant growth, grain yield, quality and metabolism of hybrid maize (*Zea mays* L.). Agronomy. 2020;10: 319.
DOI:0.3390/agronomy 10030319
22. GoI. Horticultural Statistics at a Glance 2018. Horticulture Statistics Division, Ministry of Agriculture Corporation, and Farmers' Welfare, Government of India, New Delhi. 2018;490.
23. Goldammer T. Organic Crop Production: Management Techniques for Organic Farming, 381 pp. Apex Publishers, USA; 2017.
24. Gupta S, Dikshit AK. Biopesticides: An eco–friendly approach for pest control. Journal of Bio pesticides. 2010;3(1):186–88.
25. Hazra KK, Venkatesh MS, Ghosh PK, Ganeshamurthy AN, Kumar N, Nadarajan N, Singh AB. Long–term effect of pulse crops inclusion on soil–plant nutrient dynamics in puddled rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L.) cropping system on an Inceptisol of Indo–Gangetic plain zone of India. Nutrient Cycling in Agroecosystems. 2014;100(1): 95–110. ICAR. 2021.
26. Indian Council of Agricultural Research, New Delhi. http://www. icar.org.in.
27. International Rice Research Institute, Manila, Philippines. Mani M. Invasive insect pests and their management on tapioca (*Manihot esculenta* Crantz) in India. Journal of Root Crops. 2017;43(1): 58–65.
28. Kabuluk T, Svircev A, Goettel M, Woo SG. (Eds), IOBC, Global. Ramesh P, Panwar NR, Singh AB, Ramana S, Yadav SK, Shrivastava R, Subba Rao A. Status of organic farming in India. Current Science. 2010;98(9):1190–94.
29. Karthikeyan K, Sosamma Jacob S, Purushothman M, Devi S. Effect of spinosad against major insect pests and natural enemies in rice ecosystem. Journal of Biological Control. 2008;22(2):315–20.
30. Kler DS, Kumar A, Chinna GS, Kaur R, Uppal RS. Essentials of organic farming – A review. Environment and Ecology. 2001;19(4):776–98.
31. Kopke MM. Nutrient management in organic farming systems: The case study of nitrogen. In: Nitrogen Leaching in Economic Agriculture. 1995;15–29.
32. Ladha JK, Watanabe I, Saono S. Nitrogen fixation by leguminous green manure and practices for its enhancement in tropical lowland rice. (In) Green Manure in Rice Farming. 1988;165–83.
33. Nene YL. A critical discussion on the methods currently recommended to support organic crop farming in India. Asian Agri–History. 2017;21(3):267–85.
34. Nima D, Aulakh CS, Sharma S, Kukal SS. Assessing soil quality under long–term organic vis–a–vis chemical farming after twelve years in north–western India. Journal of Plant Nutrition; 2020.
Available:https://doi.org/10.1080/01904167 . 2020.1862195
35. Panwar AS, Shamim M, Ravisankar N, Ansari MA, Singh R, Prusty AK, Noopur K. Influence of long– term fertilization with organic sources on crop productivity and soil quality in rice–wheat system under arid and sub humid conditions. Indian Journal of Fertilizers. 2021;17(6):544– 54.
36. Pimentel D. Amount of pesticides reaching target pests: environmental impacts and ethics. Journal of Agricultural Environmental Ethics. 1995;8:17–29.

37. Ponisio LC, M'Gonigle LK, Mace KC, Palomino J, de Valpine P, Kremen C. Diversification practices reduce organic to conventional yield gap. Proceedings of Royal Society B. 2015;282:20141396. https://doi.org/10.1098/ rspb.2014.1396
38. Purohit SS, Gehlot D. Trends in Organic Farming, 2006;438. Agrobios India, Jodhpur, Rajasthan. Rabindra RJ, Grzywacz D. Microbial pesticides in India. (In) Use and Regulation of Microbial Pesticides in Representative Jurisdictions Worldwide. 2010;12–17.
39. Ravisankar N, Panwar AS, Prasad Kamta., Kumar, Vipin Bhaskar S. Organic Farming Crop Production Guide, Network Project on Organic Farming, ICAR–Indian Institute of Farming Systems Research, Modipuram, Meerut, Uttar Pradesh, India. 2017;586.
40. Röös E, Mie A, Wivstad M, Salomon E, Johansson B, Gunnarsson S, Wallenbeck A, Hoffmann R, Nilsson U, Sundberg C, Watson CA. Risks and opportunities of increasing yields in organic farming– A review. Agronomy for Sustainable Development. 2018;38:14. Available: https://doi.org/10.1007/s13593–018–0489–3
41. Rupela OP, Gowda CLL, Wani SP, Ranga Rao GV. Lessons from non–chemical input treatments based on scientific and traditional knowledge in a long–term experiment; 2005.
42. Trivedi A, Pyasi S.K., Galkate RV, Gautam VK. A Case Study of Rainfall Runoff Modelling for Shipra River Basin. Int. J. Curr. Microbiol. App. Sci. 2020;Special Issue-11: 3027-3043.
43. Trivedi A, Awasthi MK. A Review on River Revival. International Journal of Environment and Climate Change. 2020;10(12): 202-210.
44. Trivedi A, Gautam VK. Decadal analysis of water level fluctuation using GIS in Jabalpur district of Madhya Pradesh. Journal of Soil and Water Conservation. 2022;21(3):250-259.
45. Trivedi A, Rao KVR, Rajwade Y, Yadav D, Verma NS. Remote Sensing and Geographic Information System Applications for Precision Farming and Natural Resource Management. Indian Journal of Ecology. 2022;49(5): 1624-1633.
46. Singh S. Re-organising agricultural markets for doubling farmer incomes in India: Relevance, mechanisms and role of policy. Indian Journal of Agricultural Economics. 2019;74(3):390-407.
47. Magnaye D. Smallholder Organic Farming: An Entrepreneurial Strategy in Harmony with Nature. International Journal of Environmental Science & Sustainable Development. 2017;2(2).
48. Giovannucci D. Organic farming as a tool for productivity and poverty reduction in Asia. InPrepared For The International Fund For Agricultural Development/Nacf Conference Seoul. 2007;13:16).
49. Aulakh CS, Ravisankar N. Organic farming in Indian context: A perspective; 2017.
50. Yadav SS, Hegde VS, Habibi AB, Dia M, Verma S. Climate change, agriculture and food security. Food security and climate change. 2019;1-24.
51. Pimentel D. Amounts of pesticides reaching target pests: environmental impacts and ethics. Journal of Agricultural and environmental Ethics. 1995;8:17-29.
52. Nielsen JG, Cohen DM, Markle DF, Robins CR. FAO species catalogue. Ophidiiform fishes of the world (Order Ophidiiformes); 1999.
53. Köpke U. Nutrient management in organic farming systems: the case of nitrogen. Biological Agriculture & Horticulture. 1995; 11(1-4):15-29.
54. Funtilana S. Safe, inexpensive, profitable and sensible. International Agricultural Development. 1990;24:20-5.
55. Askegaard M, Olesen JE, Rasmussen IA, Kristensen K. Nitrate leaching from organic arable crop rotations is mostly determined by autumn field management. Agriculture, ecosystems & environment. 2011;142(3-4):149-60.
56. Berry PM, Dawson TP, Harrison PA, Pearson RG. Modelling potential impacts of climate change on the bioclimatic envelope of species in Britain and Ireland. Global ecology and biogeography. 2002; 11(6):453-62.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/104132