

Organic Nutrient Management and Sustainable Practices for Enhancing Fruit Crop Productivity in India

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Abstract

India is one of the largest producers of fruits in the world, playing an important role in providing nutritional security, ensuring rural livelihoods and agricultural exports. Discriminate use of synthetic fertilizers and pesticides in intensive cultivation systems, however, has led to serious concerns over soil degradation and pollution, loss of biodiversity and food security. In this respect, organic horticulture has gained momentum as an alternative which is eco-compatible and sustainable to improve fruit crop productivity, playing a significant role in preserving ecological balance and long-term fertility of the soil. This current study discusses different organic practices employed in the production of fruits throughout India and its effect in enhance the productivity, fruit quality and sustainability. The study was carried out from 2022 to 2024 by using field based comparative analysis method and efforts were made with 150 fruit growers in major horticultural producing areas of India. Descriptive statistics, regression analysis and Benefit-Cost Ratio estimation were done to assess productivity and sustainability indicators as well as soil fertility under organic and conventional farming practices. The effects of major organic interventions like farmyard manure, vermicompost, green manuring, biofertilisers, biopesticides, mulching, crop diversification, and integrated nutrient management on plant growth, crop production, soil properties and pest management are discussed. This study also points to the economic and environmental advantages of organic fruit farming such as lower need for chemical use; better market prices; higher exports potential; and adaptation to climate variability and vulnerability. Low initial yields, certification requirements, lack of awareness and poor market conditions are other challenges analysed critically. The results indicate that with scientific practices combined with

policy support, farmer education and extension, and efficient value chains, organic methods can significantly enhance productivity of fruit crops. Enhancement of research and extension, strengthening organic packages for the states and creating awareness for sustainable utilization of resources are critical for future development of organic fruit farming in India. The outcomes indicated that the fruit productivity was 8-16% more in organic system than in conventional system and also it had enhanced soil organic carbon by 61.54% and water-use efficiency by 25.8% when compared to conventional system. In conclusion, the study demonstrates that organic horticulture can be a viable option for a sustainable food production and environmental protection in Indian agriculture.

Key words: Horticulture, organic, sustainability, biofertilizers, productivity.

Introduction

With fruits and vegetables being the staple food sources, India is one of the biggest producers in the world, accounting for a significant portion of the global production and food security. Horticulture is important due to its contribution to agricultural employment, nutrition, economic exports and development of poor people of rural areas (Kumar, et al, 2025). The cultivation of fruit crops is of great economic importance and has significant demand among the consumers, which makes mango, banana, citrus, guava, apple, grapes, papaya and pomegranate crops important in Indian agriculture (Government of India, 2023). In the conventional horticultural growing systems however, environmental and ecological issues are emerging as serious concerns regarding the increasing dependency on chemical fertilizers, pesticides and synthetic growth regulators for the production of horticultural crops, such as: soil degradation, decline in biodiversity, water pollution and food products contamination with residues of used pesticides (Reganold & Wachter, 2016; Bheimisetti & Gogu, 2025; Gomiero et al., 2011).

Organic agriculture has become a viable option for ensuring productivity while simultaneously safeguarding the environment and human health over the past few years (Tripathi et al., 2017). Organic horticulture uses natural inputs, biological nutrient cycling, environmentally friendly pest management practices and conserves biodiversity as the principles of ecological methods (Jain et al., 2024). Taking up the use of farmyard manure, vermiculture compost, green manuring, crop rotation, mulching, biofertilizer and biopesticide helps to enhance soil fertility, soil microbial activity, moisture-holding capacity and plant health (Kumar et al., 2018; Lampkin, 2002). Practices help to decrease the reliance on external input and promote the long-term sustainability of fruit production systems.

Over the past few years, it's been discovered by consumers around the world that healthy foods look better, taste better, smell better and are better for the environment when they are organically grown. India has a huge scope for the organic fruit production due to its diversified agro climatic conditions, traditional knowledge, and its availability of organic methods. To support sustainable horticultural development, several initiatives for enhancing the sustainability of agriculture have been introduced in various states of India, organic farming being one of them, such as in Sikkim, Uttarakhand, Northeastern states and Himachal Pradesh (Srivastava et al., 2015; Willer et al.,

2023). The cultivation of fruits without using chemicals helps achieve a healthy ecological balance, it opens the possibilities for excellence pricing, promotion for export and better farmer income.

Adapting to and mitigating the effects of climate change is cited as one of the positive contributions of organic farming systems. Using organic amendments to manage soils boosts C-sequestration, water-use efficiency, and climate change resilience (FAO, 2021). Besides, incorporation of organic nutrient management systems, along with biological pest management, helps beneficial organisms' stability and conservation (Mohanapriya et al., 2024; Srivastava et al., 2019). Despite these advantages, several restraints in the growth of organic fruit production exist in India such as low productivity during the conversion period, scarcity of the certifying system, less all technical knowledge of farmers, and less developed market infrastructure, as well as the high labor requirement (Mitra & Devi, 2016; Das et al., 2020).

The importance of introducing sustainable and economic horticultural production has steadily grown these last few years, making organic strategies in fruit crop cultivation a constantly important point of view (Pylak et al., 2019). Organic horticulture is a balanced way to strive towards sustainable agriculture, food assurance, resource stewardship and rural development. Hence, to improve the productivity of the fruit crops through organic farming is a key to nurturing sustainable horticulture in India. There are a few studies that have explored the issues associated with organic agriculture in India but there is limited studies on how the adoption of organic nutrient management in fruit crop production system will simultaneously affect the economic viability, improvement of soil fertility and sustainability indicators. Moreover, the empirical comparisons for different fruit crops between the organic and the conventional systems are still lacking in India. Hence, the present study tries to assess the efficiency of the organic methods in enhancing productivity, soil health, profitability and environmental sustainability of the fruit crop production in India.

Materials and Methods

The present study is conducted to test the effectiveness of organic technologies on the productivity of fruit crop-based products in India. The study was carried out in the selected horticultural districts of Nashik and Jalgaon (Maharashtra), Malihabad (Uttar Pradesh), Kolar (Karnataka) and Hoshiarpur (Punjab) of India. These districts have been emphasized on account of important commercial fruit cultivation and incremental changes in their organic horticultural cultivation; Nashik for the cultivation of pomegranate and grape; Jalgaon for banana crop; Malihabad for mango crop; Kolar for mango and guava crops, and Hoshiarpur for citrus crops. The choice of districts considers the agro-climatic diversity of the country to test the effectiveness of the organic farming techniques with fruit crops. Major fruit crops like mango, banana, guava, citrus and pomegranate were selected for the study, because of their economic importance, and its widespread cultivation in both organic and conventional farming system of the study regions, which are located in various climatic zones (sub-tropical, temperate and semi-arid) with rainfall of 650 mm to 1500 mm and average temperature ranging from 12°C to 32°C).

The study was comprised from both the primary and secondary data. Structured questionnaires, farmer interviews, field observations and analysis of farmers' soil samples were used to gather

primary data from selected farmer group of the organic fruit growers. District, village, and respondent sampling were done over multiple stages to identify those who utilized organic horticulture. A total of 150 fruit growers were selected for this study (with 75 being organic, and 75 conventional). The values given in the study tables are average means from orchards surveyed in the various districts chosen. The agricultural years 2022-2024 were used to collect primary data. Stratified random sampling methods were used to select the respondents to assure representation among the farm sizes and fruit crops. In campo farm management information, application of organic inputs, irrigation, pest management, yields, production costs and others were collected. Secondary data was derived from government agricultural reports, horticultural statistics, scientific papers, agricultural universities and extension agencies.

The study dealt with different organic technologies such as farmyard manure, vermicompost, using green manuring, mulches, biofertilizers, biopesticides, diversifying cropping and integrated nutrient management. All these practices were assessed in terms of its contribution to the soil fertility, moisture conservation, pest management, and fruit production. Comparative assessment was conducted between the two farming systems (organic and conventional) to determine environmental, economic and yield differences.

Fruit crop productivity was estimated by dividing the total yield obtained from fruit cultivation by the total cultivated area. The productivity model used in the study was expressed as:

$$P = \frac{Y}{A}$$

where P represents productivity in tons per hectare, Y denotes the total yield of fruit crops, and A indicates the area under cultivation in hectares. This model helped in measuring the efficiency of organic farming practices in increasing fruit production.

To assess the economic viability of organic fruit farming, the Benefit-Cost Ratio (BCR) was calculated using the following model:

$$BCR = \frac{TR}{TC}$$

where TR represents total returns obtained from fruit production and TC denotes the total cost of cultivation. A BCR value greater than one indicated that organic fruit farming was economically profitable and financially sustainable.

The growth performance of fruit productivity under organic farming was measured using the Compound Annual Growth Rate (CAGR) model:

$$CAGR = \left(\frac{V_f}{V_i} \right)^{\frac{1}{n}} - 1$$

where V_f is the final productivity value, V_i is the initial productivity value, and n represents the number of years considered in the study period. This model was used to determine the annual growth trend in organic fruit productivity.

Soil fertility improvement under organic management was evaluated through a Soil Fertility Index (SFI), which incorporated major soil nutrient parameters including nitrogen, phosphorus, potassium, and organic carbon content. The model was represented as:

$$SFI = \frac{N + P + K + OC}{4}$$

where N , P , K , and OC denote nitrogen, phosphorus, potassium. This index provided a comprehensive assessment of soil health under organic horticultural systems.

Furthermore, a Sustainability Index (SI) was used to evaluate the environmental, economic, and social sustainability of organic fruit farming systems. The index was calculated as:

$$SI = \frac{E + Ec + S}{3}$$

The location of the form of 'where' stands for environmental performance, the letter 'E' for economic performance and the letter 'S' for social sustainability. Through the sustainability index a system-wide assessment of the sustainability of organic horticulture was possible.

The data obtained were statistically treated by descriptive statistics, percentage analysis, correlation analysis and regression. Analysis of variance (ANOVA) and student t-test were used (at 5% significance level) to test for differences between the organic and conventional farming systems. Pearson correlation coefficient was also used to correlate the impacts of soil fertility parameters with fruit productivity. Data was processed and interpreted using statistical software; SPSS, R and Microsoft Excel. The results were presented in tabular, graphical and comparative format, which brought out the effectiveness of the organic approaches in boosting productivity and sustainability of fruit crops in India.

Results and Discussion

The results of the study showed that in India, organic horticulture management practices yielded remarkable improvements in fruit productivity, soil fertility, and economic benefits, as well as sustainability measures. Organic methods such as vermicomposting, farmyard manure application, mulching, green manuring, biofertilizers and biological pest management had positive impact on the growth and yield of the crops and environmental quality. It was found that while organic systems at conversion had a slight short-term negative impact, general longer-term impacts of increased soil health, viability and profitability led to substantial benefits being brought to peasants.

Productivity Performance of Organic Fruit Crops

There was considerable variability in the productivity analysis of the selected fruit crops grown under Organic farming systems. The relatively higher productivity in mango and banana was witnessed because of better nutrient management system (water and nutrient management practices). Additionally, studies showed that the hand culture of guava and pomegranate crops exhibited improved yield stability and good fruit quality in organic cultivation.

Table 1: Productivity of Selected Fruit Crops under Organic Farming Systems in India

Fruit Crop	Area under Cultivation (ha)	Average Yield (t/ha)	Conventional Yield (t/ha)	Percentage Change (%)
Mango	1,250	12.8	11.5	11.30
Banana	980	34.5	31.8	8.49
Guava	760	18.2	16.7	8.98

Citrus	640	15.4	14.1	9.22
Pomegranate	520	14.8	13.2	12.12

Note: Values represent mean observations from surveyed farms during 2022–2024. Differences were significant at $p < 0.05$.

Table 1 data reveals that in India farming practice of organics significantly aided in the productivity of fruit crop in all the selected crops. The highest average yield was obtained for banana with 34.5 t/ha harvested under Organic as compared to 31.8 t/ha harvested under Conventional farming with a productivity increase of 8.49% under Organic farming. Similarly, organic mango production also showed significant improvement with an average production of 12.8 t/ha as compared to 11.5 t/ha in conventional system of cultivation over 1250 ha of cultivated area (11.30% increase). In the same way, organic and conventional yields were 18.2 t/ha and 16.7 t/ha respectively showing an increase of 8.98% for guava. This showed a productivity increase of 9.22% in citrus with the organic growing productivity being 15.4 t/ha for chemical farming systems 14.1 t/ha. In mycorrhizal farming, the productivity gain observed for pomegranate crops was highest (12.12%, 14.8 t/ha) and from 520 ha (conventional) to 88 hectares (mycorrhizal). Overall, the results indicated that higher productivity and better yield performance for these fruit crops under an organic horticultural system was significantly attributed to organic nutrient management, improved soil fertility, enhanced microbial activity and/or sustainable crop management practices. The result of the ANOVA showed that there were significant differences in the productivity among systems of organic/conventional for all selected fruit crops ($p < 0.05$), which mean the system of nutrient management practices influenced productivity of different fruit crops favorably.

Soil Fertility Improvement under Organic Management

Soil fertility assessment showed positive impacts of organic methods of increasing nutrient availability and soil organic carbon. Sustained use of organic manures and biofertilizers resulted into better soil structure and biological activity.

Table 2: Changes in Soil Fertility Parameters under Organic Fruit Farming

Soil Parameter	Initial Value	Final Value	Percentage Increase (%)
Nitrogen (kg/ha)	210	268	27.62
Phosphorus (kg/ha)	18.5	24.7	33.51
Potassium (kg/ha)	165	214	29.69
Organic Carbon (%)	0.52	0.84	61.54
Soil Moisture Retention (%)	42	57	35.71

Note: Values represent mean observations from surveyed farms during 2022–2024. Differences were significant at $p < 0.05$.

The values given in table 2 clearly show significant enhancement of the soil fertility parameters in the organic fruit farming systems which points to the positive effect of organic nutrient management practices on soil health and sustainability. The application of biofertilizers and

organic manures resulted in an increase in nitrogen content from 210kg/ha to 268kg/ha that is equivalent to 27.62% increase which is due to improved nutrient mineralization and microbial activity. Also the availability of phosphorus increased considerably from 18.5 kg/ha to 24.7 kg/ha, too, which had the greatest nutrient improvement of 33.51%. Phosgene oxime seems to be readily available in organic management, as it probably gets better solubilized by soil microbes. Likewise, enhanced potassium uptake happened between 165 kg/ha and 214 kg/ha with an improvement of 29.69%, which helps in promoting the growth of the crop as well as fruit development. The most significant improvement is recorded in the SOC content of soils as it rose from 0.52% to 0.84%, corresponding to an increase of 61.54%. This means better soil structure, higher capacity of carbon sequestration and biological activity in organic cultivation systems. Moreover, the soil moisture holding capacity was raised from 42% to 57%, giving a 35.71% increase; this shows the potential of mulching and addition in soil organic content to improve water holding capacity and drought resistance. In general, these results reinforce the beneficial effects of organic farming methods on soil fertility, nutrient status and water holding capacity which contribute to the productivity and long-term sustainability of fruit farming. The correlation analysis showed that the fruit productivity in organic farming systems had a strong positive correlation with the SOC ($r = 0.81$).

Economic analysis of organic fruit farming

An economic assessment showed that although some additional labor and management expenses are incurred, production of organic fruits resulted in higher net returns. Fruits that were organically grown enjoyed good market prices, limiting the gap between their premium market price and their farm gate.

Table 3: Cost and Return Analysis of Organic Fruit Cultivation

Fruit Crop	Total Cost (INR/ha)	Gross Return (INR/ha)	Net Return (INR/ha)	Benefit Cost Ratio
Mango	98,000	176,500	78,500	1.80
Banana	1,25,000	2,32,000	1,07,000	1.86
Guava	82,000	1,46,000	64,000	1.78
Citrus	76,500	1,35,000	58,500	1.76
Pomegranate	1,08,000	2,04,500	96,500	1.89

Note: Values represent mean observations from surveyed farms during 2022–2024. Differences were significant at $p < 0.05$.

Organic fruit production has proved to be economically viable and profitable in all the selected fruit crops in India, as suggested by the economic analysis (table 3). In terms of gross return and net return of crops, banana turned out to be the most profitable crop with a gross return and net return of INR 2,32,000/ha and INR 1,07,000/ha respectively on a total expenditure of INR 1,25,000/ha thus giving a desirable Benefit-Cost ratio (BCR) of 1.86. Pomegranates also showed good economic performance with the highest gross return of INR 2,04,500 per hectare and also the highest net return of INR 96,500 with the highest profitability under organic cultivation with BCR value of 1.89. Mango gross return was INR 1,76,500/ha and net income obtained is INR 78,500 which is a constant economic gain of organic orchard management with BCR of 1.80. In

the same way, guava generated a net increase of profit of INR 64000/ha with a BCR of 1.78, and lowest net return but still profitable of INR 58500/ha and BCR of 1.76 for citrus farming. The results unambiguously show that organic fruit production requires still moderate production cost because the implementation is time consuming and the use of organic material, but on the other hand the market price of the exportable organic fruits yields a better profit for a farm because of reduced expenditure to chemical synthetic products in the cultivation process. In general, the findings indicate that organic horticulture can be a profitable crop enterprise and has the potential to contribute to income in the livelihoods of farmers ensuring long-term sustainability in agricultural production.

Impact of Organic Inputs on Fruits Yield

Differences in effectiveness were observed with respect to fruit crop performance as influenced by the various types of organic inputs used. Vermicompost and biofertilizers proved to be relatively effective for productivity improvement.

Table 4: Effect of Organic Inputs on Average Fruit Productivity

Organic Input	Productivity Increase (%)
Farmyard Manure	10.5
Vermicompost	16.8
Green Manuring	9.7
Biofertilizers	14.3
Mulching	11.6
Biopesticides	8.9

Note: Values represent mean observations from surveyed farms during 2022–2024. Differences were significant at $p < 0.05$.

Table 4 shows that in India, the different organic inputs significantly increased the productivity of fruit crops in organic horticulture system. In case of various inputs, vermicompost recorded the maximum level of productivity enhancement by 16.8%, which shows its better activity towards better soil fertility, microbial activity, availability of nutrients, and root development. The use of biofertilizers also resulted in significant productivity improvement of 14.3% thereby highlighting the significance of their role in nitrogen fixation, phosphorus solubilization and nutrient capture efficiency in fruit crops. The mulching practices also helped increase productivity by 11.6% due to the conservation of soil moisture, control of soil temperature, and reduction in weed competition creating favorable growth conditions for the development of crops. The farmyard manure technique gave a productivity increase of 10.5%, which showed its importance for increasing soil organic matter levels and soil health in the long-term. The productivity of green manuring was 9.7% higher than the rest of study because of its role in providing nutrient recycling and soil structure improvement. The productivity gain of biopesticides was also significant though it was lowest, (8.9%) demonstrating their effectiveness in environmentally safe weed control and minimization of crop losses due to insect pests and diseases. Considering the overall results, the outcomes of this study indicate that the use of organic inputs, when applied simultaneously, has a

significant effect on improving fruit crop productivity by increasing soil fertility, ecological balance and sustainable practices in crop production.

Sustainability Assessment of Organic Horticulture

Overall, the organic fruit system had greater environmental sustainability and ecological resilience than conventional farming systems.

Table 5: Sustainability Indicators under Organic Fruit Farming Systems

Indicator	Organic Farming	Conventional Farming
Soil Organic Carbon (%)	0.84	0.48
Water Use Efficiency (%)	78	62
Biodiversity Score	8.4	5.2
Chemical Input Use (kg/ha)	12	94
Carbon Emission (t CO ₂ /ha)	1.8	4.6

As shown in the table 5, the indicators clearly present the environmental benefits of using Organic Farming to conventional horticultural systems. The soil organic carbon (SOC) was also recorded to be higher under organic farming with 0.84% compared to conventional farming with 0.48%, which is evidence of the higher fertility of the microbially and the potential to sequester carbon sequestration under the organic farming practices. Organic systems had much greater water-use efficiency than conventional systems (78% versus 62%), and this efficiency was attributed to several aspects of organic farming, including mulching, use of organic matter to improve soil structure, and conservation of soil moisture. Interestingly, the biodiversity score was also significantly higher in organic farming systems (8.4) compared to conventional farming systems (5.2), thus indicating that low input and ecological management activities favor beneficial microorganisms, pollinators and natural enemies in the farming system. At the same time, chemical input use was very low for organic farming, 12 kg/ha, in comparison with 94 kg/ha for conventional farming, showing that the dependency on synthetic fertilizers and pesticides in organic production is reduced. Likewise, organic farming resulted in significantly reduced carbon emissions (1.8 t CO₂/ha), compared to conventional farming (4.6 t CO₂/ha), demonstrating the potential of organic horticulture with regards to climate change mitigation and reduced GHG emissions. Overall, the results confirm that organic cultivation systems are more environmentally friendly and have low resource demands than horticultural production systems in general.

Discussion

Based on the outcomes of the present study, it can be concluded that the use of organic practices can be considered an important method of increasing productivity and soil fertility for orchards grown by the horticulture sector in India and also help in ensuring environmental sustainability. The observed higher levels of productivity, under the management of organic farming systems, can largely be explained by the enhanced nutrient cycling and soil biological activity in the case of the use of organic amendments (vermicompost, farmyard manure, green manuring and

biofertilizers). It follows similar results as shown by Reganold and Wachter (2016), who highlighted the fact that organic farming systems benefit the long-term maintenance of soil health and ecological balance in addition to providing stable plant production. Organic nutrient sources stimulate populations of microorganisms, encourage more decomposition of organic matter and make nutrients more available to plants, thereby boosting plant growth and fruit production.

This suggests that sustainable nutrient management practices have significant positive effects on mango, banana, guava and pomegranate productivity. It was observed that vermicompost and biofertilizers can significantly boost the yield by enhancing the soil aeration characteristics, root development and efficiency of nutrient absorption. These results corroborate those of Yadav et al. (2013) who found that the organic nutrient management system is an efficient way of boosting horticulture productivity in the soils of the region, due to the increased soil microbial activity and nutritional efficiency. Moreover, mulching technology increased water holding capacity of soils and minimized soil moisture evaporation especially in semi-arid and water restricted areas prevalent in numerous fruit plantations of Indian sub-continent.

Soil fertility increases seen during the study support the long-term beneficial effects of organic horticulture. Organic management systems resulted in significantly higher levels of organic carbon content, nitrogen availability, phosphorous levels and potassium. Repeated application of organic amendments will enhance soil structure, microbial biomass, and cycle through sustainable methods (Lampkin, 2002). In addition, soil organic carbon is improved as C-sequestration and climate change mitigation measures. The results showed an increase in water holding capacity in organically managed soils also underscoring previous studies (Food and Agriculture Organization, 2021) showing that organic farming systems have shown higher water-use efficiency and soil resilience under changing climatic conditions.

Economic analysis showed that organic fruit was economically beneficial for farmers even, although slightly more labour was required and farmers had to pay higher certification fees, the BCRs and net returns of the organic farmers were favourable against their counterparts. The remuneration for organic fruits was able to substantially boost the profit margin and competitiveness of the market. In a similar vein, Willer et al. (2023) reported that, with global demand for organic products growing, significant economic opportunities exist for farms involved in organic horticulture. Their increasing supply of a choice of chemical-free and environmentally friendly fruit has created new domestic and global opportunities for organic products. Using less synthetic fertiliser or pesticides also decreases the overall cost of production at the long-term and the external costs of the synthetic fertiliser use for the environment.

Results of the sustainability assessment in the study pointed out that organic fruit farming systems work better than conventional systems to achieve environmental sustainability in terms of biodiversity conservation, reduction in use of chemicals in the farming area and carbon emissions. By promoting beneficial microorganisms, pollinators, and natural predators, organic farming helps maintain ecological balance, thereby enhancing ecosystem health and stability within the farming environment. These results are consistent with those of Gomiero et al. (2011), who clearly

indicated that organic farming could enhance ecosystem services and reduce environmental pollution and biodiversity conservation, when compared with the conventional farming methods. Both benefits and disadvantages have been disclosed in the study, while highlighting some of the barriers facing this technology being widely adopted in India. The low level of awareness regarding organic certification among the farmers, their low productivity in transition period, lack of extension services, shortage in market infrastructure and limited availability of organic inputs are still the major constraints in farmers' willingness to adopt organic farming practices. Das et al. (2020) also noted policy support, institutional strengthening and technical training as additional constraints for supporting the uptake of organic agriculture in developing countries. Support to the farmer, farmer education, financial incentives and improved systems of supply are all critical to meet these challenges and to ensure sustainable horticulture development. The present results also support the global research about sustainable horticulture that found the organic farming methods increase microbial diversity, improve nutrient-use efficiency, and increase the resilience of the ecosystems in a climate-stressed environment. These increases in productivity under organically managed fruiting orchards were also reported to take place in Mediterranean and European fruit production systems, especially when using integrated nutrient management and biological control strategies.

The overall conclusion of the study is; it is scientifically proven that the utilization of organic methods is a practicable and eco-friendly solution of improving productivity in the fruits production in India with greater yield. Bio-inputs can play a significant role in sustaining agricultural production with a focus on both organically grown produce and sustainable soil management practices, as well as in protecting the integrity of the food chain from integrating biological pest control. Focusing on research-led organic technologies along with encouraging market-oriented organic horticulture is to further improve transition towards sustainable production systems of fruits in India.

Limitations of the Study

The study was restricted to selected fruit-growing areas, and the emphasis was mainly put on the major fruit crops under organic management regimes. Further studies are recommended to consider more extensive and longer-term data sets on fruits, biochemical fruit quality indicators and climate-resilience indicators in broader agro-ecological regions.

Conclusions

Based on the findings of the above study, it could be concluded that the organic methods are very significant to increase the productivity of fruits, also improve the fertility of soil, farmer profit from farm and helps in making the agricultural activity sustainable in Indian fruit crop farming. Organic farming technologies like those of vermicomposting, biofertilizers, farmyard manure, mulching, green manuring, and biological pest management all beneficially influenced yield performance, soil organic carbon, water use efficiency and biodiversity, and showed negative impact the use of chemical inputs and carbon emissions. The economic study showed that organic fruit production is economical on account of higher market prices for organic fruit and the lesser use of synthetic agrochemicals. Although there are many benefits, constraints like limited

awareness of farmers, certification issues, deterioration of technical help and less adequate infrastructure of markets are still holding up the prospects of large-scale implementation of organic horticulture in India. Hence, a stronger research and development on technologies in organic agriculture and organic production models that could be adapted and applied to specific regions should be intensified; certification systems should be optimized; simultaneous training and extension programmes for organic farming technologies developed, and marketing and export markets for organic fruits and vegetables should be further established to promote the development of the organic food processing sector. The study also shows how effectively organic horticulture can help to meet the goals of Sustainable Development in the context of food security, climate action, sustainable production systems and environment conservation. More policy support, investment in sustainable and climate-resilient organic production, and inclusion of digital technologies for farm management can further pave the way for sustainable horticultural systems, securing the future of agricultural productivity, environmental conservation and rural livelihood security in India.

Ethical Statement

The authors declare that data collection from respondents was conducted with informed consent and confidentiality was maintained throughout the study.

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