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ON
A HOLISTIC APPROACH OF ORGANIC FARMING IN IMPROVING THE PRODUCTIVITY AND QUALITY OF FRUIT CROPS

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A HOLISTIC APPROACH OF ORGANIC FARMING IN IMPROVING THE PRODUCTIVITY AND QUALITY OF FRUIT CROPS[1]

By

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ABSTRACT

Fruits are rich in vitamins, minerals, antioxidants, and dietary fibers, all of which are important for human health. However, the use of chemical fertilizers, fungicides, herbicides, and insecticides during the green revolution adversely affected soil health, environment, and food safety. To address this issue, agriculture employs holistic management practices that ensure food security, environmental and social goals by utilizing locally available resources and ecological processes. Organic farming is also a holistic system that uses naturally occurring substances to manage soil nutrient status, control weeds, pests, and diseases in an environmentally friendly manner, and increase fruit productivity and quality. This review study adopts a holistic approach in order to better comprehend the management techniques employed in organic farming to improve fruit yield and quality. It illustrates the current status of organic farming globally and summarizes the findings of many research that looked into the application of integrated methods in organic farming increasing the growth, yield and qualities of fruits (such as mineral content, biochemical attributes, organoleptic attributes, and antioxidant properties etc.)

Key words: Holistic management, organic farming, biofertilizer, productivity, quality

[1]Title of the seminar paper presented as a part of course HRT 598 during Winter 2022
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CHAPTER I

INTRODUCTION

Holistic Management is a whole farm planning system that helps farmers, ranchers and land stewards better manage agricultural resources in order to reap sustainable environmental, economic, and social benefits (SRUC, 2022). A holistic approach encompasses food security, environmental and social goals. It helps restore the health of agricultural ecosystems and increases the resilience of farms to future challenges. Roger M. Savory (1995) is originally credited with the development of the term Holistic Management in agriculture that is designed to restore degraded grasslands using a method that integrates economic, social, and environmental variables (particularly movements of grazing livestock) into land management (Sullivan, 1999; CSANR, 2022). Again, agriculture faces the challenge of feeding a rapidly growing population while maintaining the capacity to provide for future generations. Future food production is jeopardized by unsustainable practices that lead to climate change, depletion of non-renewable resources, and water pollution. Holistic farming systems that ensure high productivity by making use of locally available resources and ecological processes are more suitable to meet these challenges than reductionist approaches whose focus is on maximum productivity alone (Garnett and Godfray, 2012).Organic agriculture is a holistic system considered to sustain and enhance the profitability of organic yield (Smith et al., 2019). Organic farming is a sustainable approach that has a positive impact on the environment and health of human beings and wildlife because no agrochemicals such as pesticides, insecticides, herbicides and synthetic fertilizers are used as compared to conventional farming (Leifeld, 2012). The traditional knowledge and entrepreneurial abilities of farmers are also essential to sustainable agricultural systems(IAASTD, 2008) and include both organic farming and agro-ecological methods. The IFOAM General Assembly organized in June 2008 in Italy defined organic agriculture as “a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines traditional practices, innovation, and scientific advancements to improve the environment and encourage fair relationships, ensuring a good quality of life for everyone involved. The principle of "feeding the soil, not the plant" in organic farming highlights the importance of food security and soil health.

To elaborate, organic farming is a holistic approach developed to maximize the productivity and health of diverse communities in the ecosystem, including human, plant, and soil fauna. Scientific studies proved that organically grown foods have more nutrient density than those grown conventionally (Mie *et al.,* 2017).Therefore, organic agriculture is being advocated as one of the sustainable agricultural systems that not only help minimize externalities of the high input-based agriculture but also increases human nutrition by providing diversified crops including fruits, vegetables and livestock (Lampkin, 2003).

Furthermore, healthy soils are key to biodiversity, food security and play a fundamental role in fighting climate change. By fostering the transition to organic agriculture, we are contributing to healing our soil worldwide by ending their chemically-induced depletion and strengthening their potential as carbon-consuming sinks. Therefore, there is a need to move towards sustainable land management that incorporates holistic methods such as organic farming and agroecology, in conjunction with the protection and restoration of natural ecosystems like forests and peatlands. Whereas, preserving the soil is the key for ensuring mitigation and adaptation in the face of the current climate crisis. Organic farming is, therefore, a holistic system for quality crop production not even endangering the soil as well as the climate.

Objectives:

- ✓ To provide a comprehensive overview of the global status of organic farming.
- ✓ To assess the impact of organic farming and holistic management practices on fruit productivity and quality.

CHAPTER II

MATERIALS AND METHODS

This seminar paper is completely a review paper. Therefore, all of the information has been collected from secondary sources to prepare this paper. During the preparation of this paper, I went through various relevant books, journals, reports, publications etc. For collecting recent information internet browsing was also being practiced. Good suggestions, valuable information and kind consideration from my honorable major professor and course instructors were taken to enrich this paper. After collecting necessary information, it has been compiled and arranged chronologically for better understanding and clarification.

CHAPTER III

REVIEW OF FINDINGS

3. GLOBAL HISTORY, STATUS AND ECONOMICS

3.1.1. History

The origin of the concept of organic farming is actually primitive. The development of organic agriculture dates back to the beginning of the 20th century. It started as a reaction against industrialization of agriculture and was a response to concerns over the use of mineral fertilizers and pesticides (Merrill, 1983; Conford, 2001). In the 1920s, the 'Life Reform Movement' (Lebensreform Bewegung) in Germany was at the forefront of organic agriculture's emergence. The movement opposed urbanization and industrialization, extolling the virtues of vegetarianism, self-reliance, natural medicine, allotment gardens, outdoor work, and conservation of nature (Vogt, 2001). Rudolf Steiner, an Austrian, is credited with introducing the first recognizable form of organic agriculture - biodynamic agriculture. He delivered a series of lectures in 1924 (Steiner, 1924), which he later published as "Spiritual Foundations for Renewal of Agriculture," where he coined the term. (Heckman, 2006; Paull, 2011a, 2011b). However, in the later 20th century, the use of chemicals in agriculture began to be widespread. Crop yield increment then became a challenge and “The Green Revolution” started in the 1960s, using chemical fertilizers (Altieri and Nicholls, 2001; Atreya *et al*., 2011; Garcia-Yi *et al*., 2014). During an organic agriculture congress in Versailles (France) in 1972, five organic organizations formed the International Federation of Organic Agriculture Movements (IFOAM) to promote the global adoption of organic agriculture. Since then, IFOAM has been responsible for setting standards, developing certification procedures, and helping to increase the area under organic cultivation in response to growing demand for organic produce.

3.1.2. Global Organic Agriculture Status

About 38% of earth’s land cover is occupied by agriculture (FAO, 2015). Although organic agriculture currently covers only 1.6% of the world's agricultural land, its prevalence is growing rapidly. According to a survey conducted by the Research Institute of Organic Agriculture (FiBL) and IFOAM in 2022, organic practices are now used on more than 74.9 million hectares of agricultural land across more than 190 countries, compared to just 11 million hectares in 1999 (Willer *et al.,* 2022).

Table 1. Organic agricultural land and regions' shares of the global organic agricultural land 2020

Region	Organic agricultural land (hectares)	Regions' shares of the global organic agricultural land
Africa	2086859	2.78 %
Asia	6146235	8.20 %
Europe	17098134	22.82 %
Latin America	9949461	13.28 %
North America	3744163	5.00 %
Oceania	35908876	47.92 %
World	**74926006**	**100.00%**

Source: (Willer *et al.*, 2022)

According to Willer *et al.*, (2022) Oceania accounts for almost half of the total organic agriculture land worldwide with the land area of 35.9 million hectares (Mha) followed by Europe (17.1 Mha), Latin America (9.9 Mha), Asia (6.1 Mha), North America (3.7 Mha) and Africa (2.1 Mha), as shown in Table 1 .

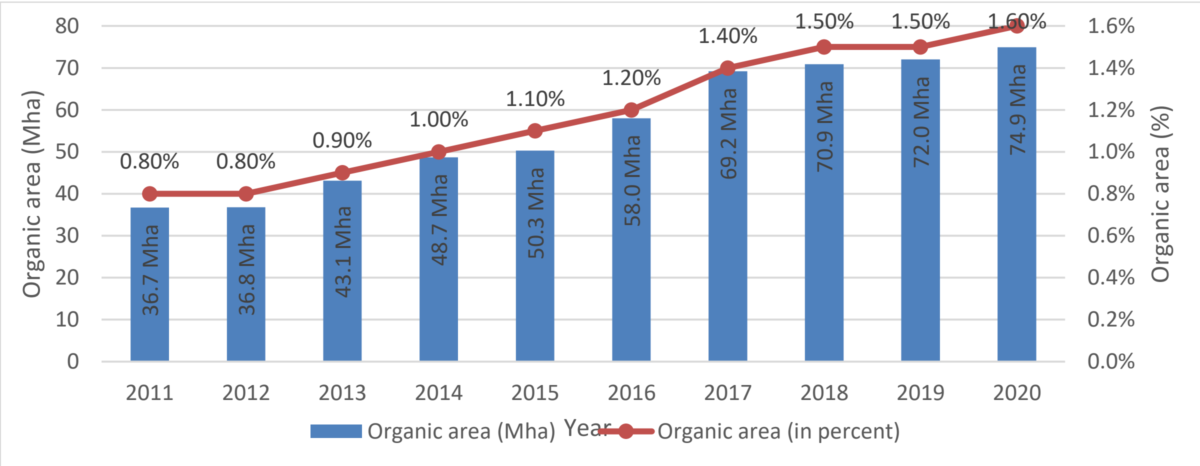

Figure 1. Growth of the organic agricultural land and organic share in past 10 years (during 2011-2020)

Source: Willer *et al.*, 2022

According to the FiBL-IFOAM report (Willer *et al.*, 2022), organic farmland increased by 3.0 million hectares (4.1 percent) in 2020 since 2019.

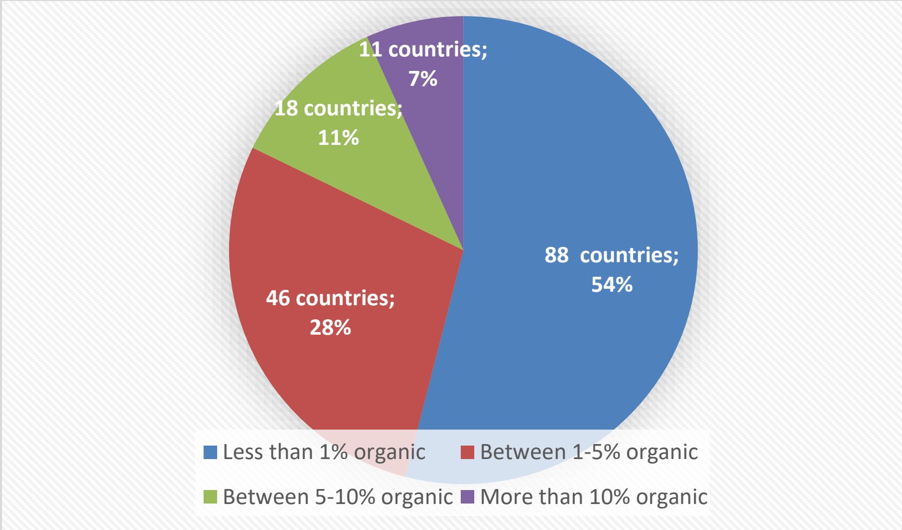

Figure 2. Distribution of the organic shares of the agricultural land in 2020
Source: (Willer *et al.*, 2022)

The survey also showed that 88 countries (54%) have less than 1% organic land while another 46 countries (28%) have 1-5% organic share and among the rests, 18 countries have 5-10% and 11 countries have more than 10% organic land (Willer *et al.*,2022).

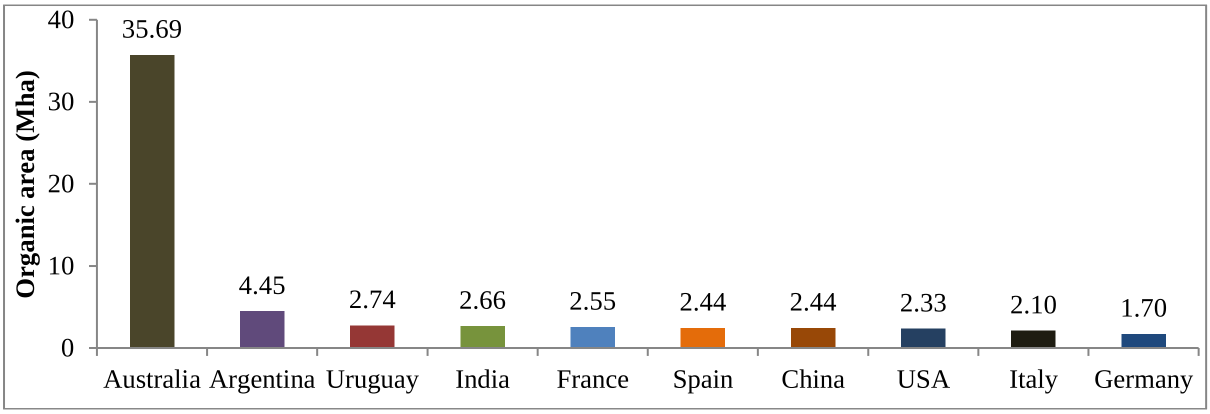

Figure 3. The top ten countries with the largest areas of organic agricultural land in 2020
Source: (Willer *et al.*, 2022)

Australia had the largest organic land area in the Oceania region as well as the country became the top of the world having had the largest individual organic area of 35,687,799 hectares representing 47.63 % of the global organic farmland. Whereas, USA, Argentina, India, France and Tunisia were the toppers in North America, Latin America & the Caribbean, Asia, Europe and Africa regions, respectively in terms of organic agricultural land shares (Willer *et al.*, 2022). Again, the leading ten countries constitute about 78.86 % of the world's organic agricultural land and the ten countries are Australia, Argentina, Uruguay, India, France, Spain, China, USA, Italy and Germany shown in figure 3.

3.1.3. Economics

Over the last 20 years, the global market for organic products has grown dramatically, notably in developing nations. Organic food sales increased steadily specially from the late 20th century.

Table 2. Organic producers, Retail sales and per capita consumption by region in 2020

Region	Producers (no.)	Retail sales (Million €)	Per capita consumption (Million €)
Africa	833986	16	0.01
Asia	1808464	12540	2.7
Europe	417977	52000	63.2
Latin America	270472	778	1.2
North America	22448	53717	147.5
Oceania	15930	1594	38.4
World	**3368254**	**120647**	**15.8**

Source: (Willer *et al*., 2022)

According to FiBL-IFOAM survey (Willer *et al.*, 2022), there were at least 3.4 million organic producers in 2020. Fifty-six percent of the world's organic producers are in Asia, followed by Africa (24 %), Europe (12 %) and Latin America (8 %). While, maximum retail sales were occurred in North America (53717 million euros) followed by the markets of Europe (52000 million euros), Asia (12540 million euros), Oceania (1594 million euros), Latin America (778 million euros) and Africa (16 million euros) regions in 2020. The survey also stated that organic food and drink sales reached more than 120 billion euros in 2020.

3.2. BASIC CONCEPT AND PRINCIPLES FOLLOWED IN ORGANIC FARMING

Organic farming, as an outcome of different assessments of economic, ecological and social goals, consequently, technique strategies such as integrated pest management of balanced nutrient supply might improve conventional agriculture to such as an extent that it may appear unnecessary to strictly ban pesticides and mineral fertilizers as required by organic standard. This concept of organic farming encourages the following basic issues (Chandrashekar, 2010).

1. The goal is to rely on local resources as much as possible and work within a self-contained system.
2. Ensuring that the soil remains fertile in the long term is a priority.
3. All forms of agricultural techniques that may lead to pollution should be avoided.
4. The aim is to produce high-quality, nutritious food in adequate amounts.
5. Minimizing the use of fossil fuels in agriculture is crucial.
6. Providing opportunities for agricultural producers to earn a livelihood and grow as individuals is a key objective.

Organic farming is a farming system that prioritizes keeping the soil healthy and alive through the use of organic and biological materials such as crop and animal waste, and beneficial microbes. The aim is to sustainably increase crop production while creating an eco-friendly and pollution-free environment. The four ethical principles that organic farming methods align with are health, ecology, fairness, and care. (IFOAM, 2005, 2010; Gonciarov *et al*., 2014).

a) Principle of Health

"Organic agriculture should sustain and enhance the health of soil, plant, animal, humans and planet as one and indivisible".

b) Principle of Ecology

"Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them".

c) Principle of Fairness

"Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities".

d) Principle of Care

"Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment".

3.3. MANAGEMENT APPROACHES IN ORGANIC FARMING

Effective management of nutrient, weeds, insect-pest and disease is the major challenge for successful organic farming. Integrated management comprising cultural, mechanical and biological practices are warranted for managing nutrient, weeds, pest and diseases in an eco-friendly way in organic farms

3.3.1. Nutrient Management

Soils are a non-renewable resource on which 95% of our food supply depends. Short-sighted chemical fertilizer applications in industrial farming are depleting soils at an alarming rate. Inorganic fertilizers, which are supposed to circumvent the soil's natural processes and feed plants directly, are not allowed, making it difficult to control nutrients in organic farming systems.

a) Green Manure

A large number of fast growing nitrogen fixing crops like dhaincha (*Sesbania* sp.), sunhemp and cowpea may be used as green manure which can fix atmospheric nitrogen to the extent of 60-100 kg/ha. Generally, dhaincha (*Sesbania esculenta, S. rostrata*) and sunhemp (*Crotolaria juncia*) are ploughed in the soil after about 6 to 8 weeks of sowing when adequate vegetative growth is attained. Use of green manure is highly beneficial for organic production and maintaining soil health. Besides adding nutrients into the soil, green manures also improve the physical and microbial properties of the soil.

b) Farm Yard Manure

The manure prepared using cow urine, dung and farm waste in the backyard space is termed as farm yard manure. This method has been followed from old times. The soil physical property, microbial activity and yield have been increased considerably using FYM. If the dung and urine from cattle are effectively collected, nearly 70 to 80 per cent of energy fed to as crop residues can be recovered back. As much as 80 to 90 per cent of N, 60 to 70 per cent of P and 60 to 75 per cent of K contained in the crop residues fed to cattle are excreted by them in the form of dung and urine.

c) Enriched Compost

One of the traditional sources for the crop nutrient is through composting the organic residues. Though nutrient concentration is less, apart from NPK it also provides the required micro-nutrients to the areas cultivated. Micro-nutrient supply satisfies particularly the hidden hunger in the plants and safeguards it against the injury and toxicity. It also improves chemical, physical and biological properties of the soil. In addition, compost are enriched externally through microbial inoculants, bio fertilizers etc. It is found that in cucumber, the application of compost increased the yield (Nair and Ngouajio, 2010).

d) Vermicompost

The technology uses earthworm as a natural bio-rectors for recycling the non-toxic organic waste to soil. Vermi-compost refers to the manure generated through rearing earthworms in large scale either in natural or artificial pit. This technique is typically employed in cases where there is a large quantity of organic matter that has yet to break down. (Chauhan *et al.,* 2010; Chatterjee *et al.,* 2014). Using high concentrations of vermicast and vermitea can improve plant health, enhance growth, provide protection, and optimize crop yields.

f) Oil Cakes (Concentrated Organic Manure)

The oil cakes are applied in the granular form before the fertilizer use, so that nutrients that are contained in them are available for the crops. This enriches the soil organic carbon to soil that in turn increases the microbial activity. Castor cake, neem cake and linseed cakes are few examples of non edible cakes. As most of the edible cakes are fed to cattle as concentrates the use of it as nutrient source is limited in Indian scenario.

g) Crop Residue

Soil fertility, soil organic matter and crop yield increases with the application of crop residues. Vegetable crop generates a huge quantity of crop residues after the harvest of their economic part. The nutrients that are embedded in residues are a potential source of the organic nutrition. They can also be used to produce vermi-compost.

h) Bio-fertilizers

Biofertilizers are the cultures of the appropriate microbial species that can fix the atmospheric nitrogen such as *Azospirillium* and *Azotobacter* in non-leguminous and *Rhizobium* species in the leguminous crops. The phosphate mobilizing fungi (VAM) and phosphate solubilizing bacteria are found more efficient in making the unavailable soil phosphorous available for the plants. It is found that legume-rhizobium association could fix 40-120 kg/ha of nitrogen under optimum conditions. The crops innoculated with Mycorrhizal fungi are found resistant to *Fusarium oxysporum, Rhizoctonia solani*, *Phythium* and nematode. Biofertilizers viz: *Rhizobium*, *Azotobacter*, *Azospirillum*, PSB Azolla, VAM and *Pseudomonas*, etc. have been found to be very effective tools of fertility management and biological nutrient mobilization.

3.3.2. Weed Management

In weed management approach under organic system, the central goal is to reduce weed competition and reproduction to a level that the farmer can accept. In many cases, this will not completely eliminate all weeds. Weed management should reduce competition from by preventing the production of weed seeds and perennial propagules - the parts of a plant that can produce a new plant. Consistent weed management can reduce the costs of weed control and contribute to an economical crop production system. Weeds in organic farming system are controlled in following ways-

A. Cultural Practices

a) Crop Rotation b) Cover Crops c). Intercropping d) Mulching

e) Stale Seedbed Preparation f) Soil Solarization

B. Mechanical Control

Mechanical removal of weeds is both time consuming and labor-intensive but is the most effective method for managing weeds especially in a organic farm. Mechanical weed control involves the use of farming tools such as hoes, harrows, tines, brush weeders, mowers, stemmers, and dual-purpose implements. The specific tool used, as well as the timing and frequency of its application, are determined by the crop and weed characteristics.

C. Biological Control

Biological control comprises the introduction of a target weed's natural enemies (insects, mites, and pathogens), which will reduce the weed density to a manageable level. It is a cost-effective, environmentally friendly, and sustainable management strategy.

3.3.3. Pest and Disease Management

The pest control strategies in organic farming are targeted in reducing and preventing the aggregation of the insect population. The risks in pest outbreaks are minimized by enriching the soil with compost, crop rotation, inter-cropping and conservation tillage (Niggli, 2010). Strategy for the pest control in the organic farming limits the use of chemical pesticides and promotes the use of organically derived pesticides. Soil solarization that are associated with the organic fertilization have a potential role in controlling nematodes (da Silva *et al*., 2006).The physical treatments of seeds like hot air, hot water and electron treatments can moderately control some of the diseases. Biological methods are also used for controlling, where they are found more prominent in the green house condition than in open field conditions. In organic farming system the following practices are, therefore, followed for pest and disease protection.

a) Tillage, land configuration and crop spacing, b) Soil solarization, c) Multiple cropping and mixed cropping, d) Use of resistant varieties, e) Mechanical methods, f) Use of Bio-pesticides, g) Use of botanical pesticides

Table 3. Some bio-control agents for controlling fruit crop diseases

Bio-control agents	Diseases
Trichoderma harzianum	Anthracnose (*Colletotrichum musae* in banana), Gray mold (*Botrytis cinerea* in grape, kiwifruit, pear, strawberry), Anthracnose (*Colletotrichum gloeosporioides* in rambutan), Brown spot (*Gliocephalotrichum microchlamydosporum* in rambutan), Stem end rot (*Botryodiplodia theobromae* in rambutan)
Trichoderma viride	Green mold (*Penicillium digitatum* in citrus), Gray mold (Botrytis cinerea in strawberry), Stem-end rot (*Botryodiplodia theobromae* in mango)
Trichoderma spp.	Sour rot (*Geotrichum candidum* in citrus), Fruit rots (*Lasiobasidium theobromae* and *Rhizopus* spp. in guava, mango)
Acrimonies brevae (Sukapure & Thirumulachar) Gams	Gray mold (*Botrytis cinerea* in apple)
Aureobasidium pullulans	Monilinia rot (*Monilinia laxa* in banana), Penicillium rots (*Penicillium* spp. in citrus), Soft rot (*Monilinia laxa* in grape)

Bio-control agents	Diseases
Bacillus subtilis	Brown rot (*Lasiodiplodia theobromae* in apricot), Stem end rot (*Botryodiplodia theobromae* Pat. in avocado), Green mold (*Penicillium digitatum* in citrus), Stem end rot (*Botryodiplodia theobromae, Phomopsis citri* Fawc.*, Alternaria citri* Ell.& Pierce in citrus)
Pseudomonas fluorescens Migula	Gray mold (*Botrytis* Ruehle in apple)

Source: (Babita *et al.*, 2015)
This table shows that certain types of bio-control agents can be used to control different fruit diseases organically.

3.4. ORGANIC FARMING IN FRUIT CROP PRODUCTION

3.4.1. Fruit yield and productivity

All the living beings have the natural tendency to produce their off-springs. With the go of the nature, plants send and preserve its formulated and uptaken nutrients to fruits as sink after use for normal growth. Organic nutrient supply significantly improve yield over control but organic yield is to some extent lower than conventional yield in most of cases. Relative yield of fruit crops is about 72% (28% lower than) of conventional yield (De Ponti *et al.*, 2012) and this phenomenon is comparatively worse than other crops. Among the temperate fruit crops, organically grown apple and strawberries yielded 69% and 59% of the synthetic chemical used farm while the other fruit crops namely grapes, melons, apricot, blackcurrant, cherry, kiwi, peach, pear from Europe and Turkey had 78% productivity in organic cultivation than that of conventional farming (De Ponti *et. al.*, 2012). Sau *et al.* (2017) reported that among the different treatments of biofertilizer, [*Azotobacter chorococcum* + *Azospirillum brasilense* + AM (*Glomus musseae*) + Panchagavya 3%] showed maximum fruit weight (237.12 g), yield (42.14 kg plant^{-1}). Again, the highest yield of 23.99 tons per hectare and a bunch weight of 9.60 kg were obtained in banana cultivar Nendran (AAB) when a combination of 10 kg of farmyard manure, 1.25 kg of neem cake, 5 kg of vermicompost, 1.75 kg of wood ash, triple green manuring with cowpea, and biofertilizers (25 g of arbuscular mycorrhizal fungi, 50 g of Trichoderma harzianum, 50 g of phosphate-solubilizing bacteria, and 50 g of Azospirillum per plant) were used. (Manju and Pushpalatha, 2022).

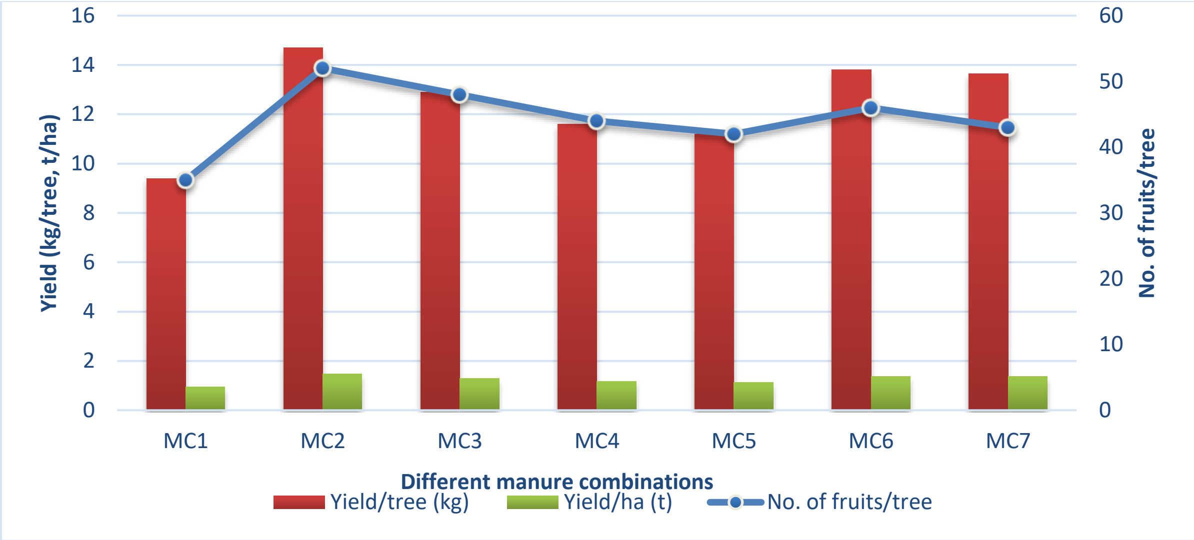

Figure 4. Effect of organic package on fruit yield of mango cv. Alphanso

(Source: Dheware *et al*., 2020)

Here, MC_1: FYM (50 kg/plant), MC_2: FYM (50 kg/plant) + *Azospirillum culture* (250 g/tree) + PSB @ 250 g/tree, MC_3: FYM (50 kg/plant) + *Azotobactor* (250 g/tree) + PSB @ 250 g/tree, MC_4: Vermicompost (50 kg/plant), MC_5: Vermicompost (50 kg/plant) + *Azospirillum culture* (250 g/tree) + PSB @ 250 g/tree, MC_6: Vermicompost (50 kg/plant) + *Azatobactor* (250 g/tree) + PSB @ 250 g/tree and MC_7: Vermicompost (50 kg/plant) + *Azospirillum culture* (250 g/tree) + PSB @ 250 g/tree + Vermi wash foliar spray

In mango, application of FYM (50 kg/plant) + *Azospirillum culture* (250 g/tree) + PSB @ 250 g/tree produced superior yield (52.00 fruits/tree, 14.70 kg/tree, 1.47 t/ha) over other organic treatment along with control (Dheware *et al*., 2020).

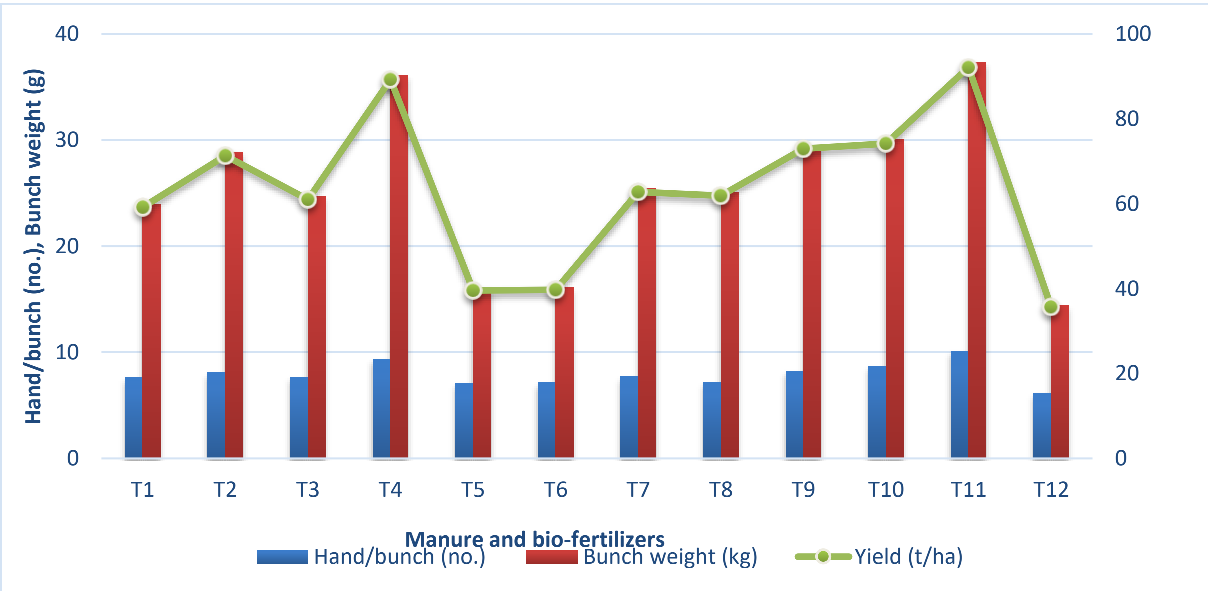

Figure 5. Effect of different organic manures and bio-fertilizers on yield and its attributes of banana cv. Grand Naine (AAA)

(Source: Hema *et al*., 2016)

Here, T_1: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg); T_2: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (14.20 kg); T_3: FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (2.36 kg); T_4: FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (9.94 kg); T_5: T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop; T_6: AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_7: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop; T_8: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_9: FYM

(10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop+AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_{10}: Poultry manure (10 kg)+Neem cake (1.875 kg); T_{11}: 200 g N+50 g P+200 g K; T_{12}: $N_0+P_0+K_0$

Yield characters viz., hands bunch-1, fruit length, fruit girth, bunch weight, yield ha^{-1} were higher with extended synthetic fertilizer dose and among organic treatments, FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (9.94 kg) recorded higher yield attributes in banana cv. Grand Naine (AAA) (Hema *et al.*, 2016).

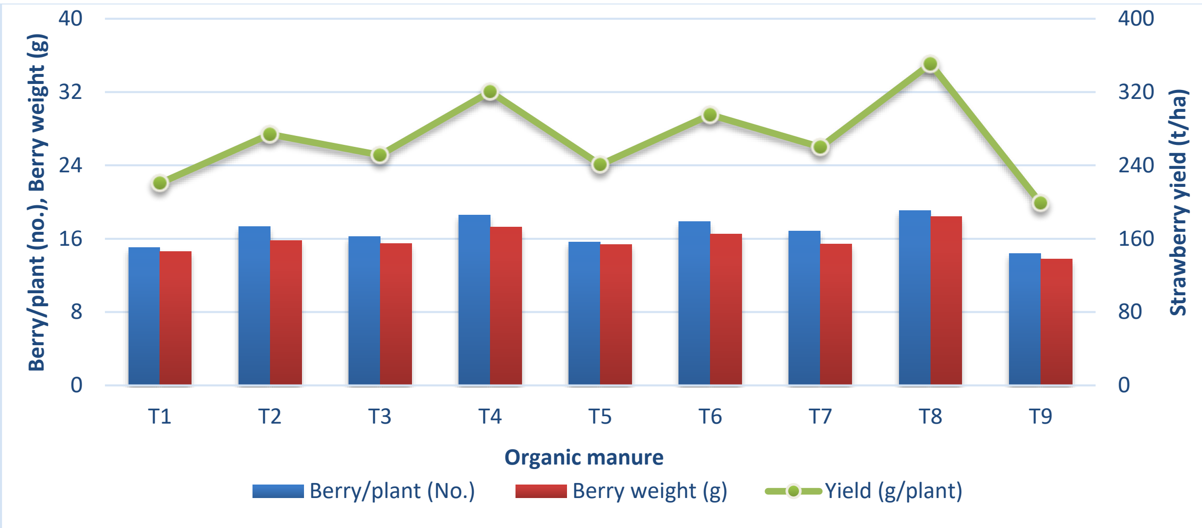

Figure 6. Effect of organic manures on yield and yield attributing parameters of strawberry

(Source: Sahana *et al.*, 2020)

Here, T_1: 100 per cent RDN through FYM, T_2: 100 per cent RDN through FYM + Jeevamruth @ 500 ml per pot at two stages, T_3: 100 per cent RDN through FYM + Beejamruth seedling treatment, T_4: 100 per cent RDN through FYM + Jeevamruth @ 500 ml per pot at two stages + Beejamruth seedling treatment, T_5: 100 per cent RDN through vermicompost, T_6: 100 per cent RDN through vermicompost + Jeevamruth @500 ml per pot at two stages, T_7: 100 per cent RDN through vermicompost + Beejamruth seedling treatment, T_8: 100 per cent RDN through vermicompost + Jeevamruth @500 ml per pot at two stages + Beejamruth seedling treatment and T_9: Recommended Dose of Fertilizers (150:100:120 kg/ha)

Application of Vermicompost + Jeevamruth @ 500 ml per pot + Beejamruth seedling treatment gave superior yield and yield attributes (berry length 4.31 cm, berry diameter 3.48 cm, berry weight 18.41 g, number of berries/ plant 19.05 and yield/ plant 350.79 g) in strawberry (Sahana *et al.*, 2020).

3.4.2. Fruit mineral content

Organic fertilizers largely add a complex combination of nutrient elements in soil; so as in fruits of organically treated plants. Mineral contents of fruits were found to be higher in fruits produced under organic systems in comparison to the fruits produced under conventional systems(Jadczak *et al.*, 2010). Kai and Adhikari (2021) investigated that fruit mineral content specially C, N, P, K of apple varied with organic and inorganic fertilization (Table 4). Likewise, Harhash and Ahmed (2018) analyzed that NPK content of mango fruits differed in different organic and chemical fertilizer treatments (Table 5).

Table 4. Mineral content of apple fruits in organic and inorganic fertilization

Treatment	Carbon (mg/kg)	Nitrogen (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)
Organic fertilizer	76283	518	483	2250
Chemical fertilizer	84240	480	367	2833

Source:(Kai and Adhikari, 2021)

Table 5. Effect of organic and mineral fertilization on NPK contents on fruits of Ewaise mango

Treatment	N (%)	P (%)	K (%)
100% mineral fertilizers (NPK) as control	1.93	0.26	1.63
50% NPK+ 100% plant compost (P.C)	1.80	0.25	1.60
50% NPK+ 100% animal compost (A.C)	1.93	0.28	1.70
100% plant compost (P.C)	1.60	0.21	1.30
100% animal compost (P.C)	1.70	0.22	1.50
50% plant compost +50% animal compost	1.60	0.20	1.40
50% (NPK+ plant compost+ animal compost)	2.50	0.34	2.05
100% (NPK+ plant compost+ animal compost)	2.88	0.39	2.50

Source: (Harhash and Ahmed, 2018)

From table 5 we can see that combination dose of 100%(NPK+ plant compost + animal compost) fertilization provide higher NPK content in fruits of Ewaise mango followed by 50%(NPK+ plant compost+ animal compost) dose.

3.4.3. Fruit biochemical attributes

In general, organically produced fruits possess significantly higher total soluble solids (TSS) and lower titratable acidity (TA) in comparison to the conventionally produced fruits (Turemis, 2002; Cayuela *et al.*, 1997); for example, sensory attributes are important aspects of fruit quality, and the balance between sweetness and sourness are the most important determinants of overall quality of fruits (Shamaila *et al.*, 1992); for example, acceptance of the flavor quality of strawberry fruits is minimum 7% for TSS content, while the maximum is 0.8% for TA (Kader, 1999). Organically grown strawberries had significantly higher TSS (7.1%) and lower TA content (0.93%) in comparison to the conventionally grown strawberries that had 6.6% TSS and 0.99% TA. While, ascorbic acid content in fruits is cultivar dependent according to

Leskinen *et al*., (2002); The levels of ascorbic acid found in fruits produced using organic farming methods were consistently greater than those found in conventionally grown fruits. (Asami *et al*., 2003). The berry fruits treated with organic methods had the highest content of ascorbic acid (50.5 mg per 100 g of fresh fruit weight), whereas the fruits treated with conventional methods had the lowest content of ascorbic acid (41.25 mg per 100 g of fresh fruit weight) according to Abu-Zahra *et al*. (2007). On the other hand, Cayuela *et al.*, (1997) did not find significant difference in the ascorbic acid content between organic and conventional grown strawberry fruits. In spite of that, the anthocyanin content of the control treatment of strawberry plants remained within the ranges between 17.8 and 41.8 mg 100 g^{-1}, and values lower or higher than that range should not be acceptable (Abu-Zahra et al., 2007). *Azotobacter chorococcum* + *Azospirillum brasilense* + AM (*Glomus musseae*) + Panchagavya 3%] exhibited superiority in fruit biochemical qualities like TSS (19.70° Brix) and total sugars (13.41%) along with prolonged shelf life of 10 days in mango (Sau et al., 2017). Easmin *et al*., 2020; Sharma and Negi (2019) and Rahman *et al*. (2021) observed similar trends in fruit biochemical properties in papaya (Table 6) and banana (Table 7), respectively.

Table 6. Influence of organic and inorganic fertilizers on fruit biochemical properties of papaya

Treatment	Dry matter (%)	TSS (%)	Total sugar (g/100g)	Ascorbic acid (mg/100g)	β-carotene (mg/100g)
T_1	2.57	8.43	5.29	22.67	0.17
T_2	3.70	15.17	7.13	24.45	0.21
T_3	3.36	10.30	5.77	23.67	0.18
T_4	3.56	14.70	6.77	23.51	0.18
T_5	3.33	11.83	5.50	22.60	0.16
T_6	3.46	11.40	5.73	24.22	0.19
T_7	3.63	16.40	7.67	24.99	0.23
T_8	3.60	14.93	6.23	23.67	0.21
T_9	3.26	13.20	6.10	23.22	0.18
T_{10}	4.37	18.17	9.43	24.67	0.24
T_{11}	3.43	13.80	6.43	22.00	0.19
T_{12}	4.33	17.30	9.10	24.33	0.23

Source: (Easmin *et al*., 2020)

Here, T_1: Control T_2: 100% Recommended dose of fertilizer (225: 100: 225 g N- P_2O_5 - K_2O per plant) follow the fertilizer recommendation guide (BARC, 2012) T_3: 50% Recommended dose + 50% Mustard Oil Cake (2.25 kg/ plant) T_4: 50% Recommended dose + 50% Vermicompost (6.25 kg/ plant) T_5: 50% Recommended dose + 50% Poultry Manure (9.25 kg/ plant) T_6: 25% Recommended dose + 75% Mustard Oil Cake (3.8 kg/ plant) T_7: 25% Recommended dose + 75% Vermicompost (9.4 kg/ plant) T_8: 25% Recommended dose + 75% Poultry Manure (13.8 kg/ plant) T_9: 100% Mustard Oil Cake (4.5 kg/ plant) (BARC, 2012) T_{10}: 100% Vermicompost (12.5 kg/ plant) (BARC, 2012) T_{11}: 100% Poultry Manure (18.5 kg/ plant) (BARC, 2012) T_{12}: Mustard Oil Cake (1.5 kg/ plant) + Vermicompost (4 kg/ plant) + Poultry Manure (6 kg/plant)

The maximum amount of TSS content was found in T10 (18.17%) which was statistically similar to T12 (17.30%). The maximum amount of total sugar was found in T10 (9.43 g/100g) treatment which was statistically similar to T12 (9.10 g/100g). The highest amount of ascorbic acid content was found in T7 (24.99 mg/ 100g) treatment. The highest β-Carotene content was observed in T10 (0.24mg/ 100g) treatment which was closely related to T12 (0.23 mg/ 100g) and T7 (0.23 mg/ 100g) treatments.(Easmin *et al.*, 2020)

Table 7. Effect of different doses of organic fertilizers on fruit biochemical properties of banana

Treatment	TSS (ºBrix)	Titratable acidity (%)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
FYM+ Microbial consortia	25.72	0.23	11.23	12.11	23.30
Enriched compost	24.46	0.25	9.12	10.68	19.83
Vermicompost	25.15	0.22	10.36	10.92	21.255
Microbial consortia	25.02	0.19	10.74	11.57	22.50

Source: Rahman *et al.*, 2021

This table shows that FYM+ Microbial consortia Provide higher TSS, reducing sugar, non-reducing sugar and total sugar.

3.4.4.Soil health and microbial population

The organic treatments recorded significantly higher soil respiration and mineralizable nitrogen content compared to recommended dose of fertilizer and control treatment. Similarly, Mitra *et al.* (2010) and Sau *et al.* (2017) noticed that application of organic manures along with biofertilizers substantially increased soil microbial population which improved soil health as well as availability of other essential nutrient elements and thereby the growth and productivity of the tree (Table 8).

Table 8. Effect of biofertilizers on soil properties of mango orchard (cv. Himsagar)

Treatment	Soil pH	Available N	Available P	Available K	Bacteria (cfu/g of soil)
T_1	6.61	182.11	96.19	299.14	2.6×10^6
T_2	6.62	181.37	96.21	299.72	2.7×10^6
T_3	6.60	182.92	96.11	290.12	2.3×10^6
T_4	6.59	182.72	96.23	299.77	2.9×10^6
T_5	6.69	183.00	96.72	300.00	2.9×10^6
T_6	6.84	183.11	96.91	301.00	3.0×10^6
T_7	6.91	184.35	99.17	311.23	3.1×10^6
T_8	6.61	183.42	99.00	299.00	2.6×10^6
T_9	6.52	183.92	94.11	291.00	2.0×10^6
T_{10}	6.50	181.00	93.12	272.00	2.1×10^6

Source: (Sau *et al*., 2017)

Here, T_1: *Azotobacter chorococcum* + Panchagavya 3%, T_2: *Azospirillum brasilense* + Panchagavya 3%, T_3: AM (*Glomus musseae*) + Panchagavya 3%, T_4: *Azotobacter chorococcum* + *Azospirillum brasilense* + Panchagavya 3%, T_5: *Azotobacter chorococcum* + AM + Panchagavya 3%, T_6: *Azospirillum brasilense* + AM + Panchagavya

3%, T_7: *Azotobacter chorococcum* + *Azospirillum brasilense* + AM + Panchagavya 3%, T_8: Panchagavya 3%, T_9: N:P:K (1000:500:1000 g $plant^{-1}$ $year^{-1}$), T_{10}: Control

3.4.5. Fruit organoleptic attributes

Organic production of fruit improves fruit quality viz. fruit taste, colour, keeping quality of the fruits than conventionally produced fruits (Table 9).

According to Rembiałkowska (2007) organically produced crops usually have better sensory and long-term storage qualities. Many studies have proved quite unequivocally that vegetables and fruits from organic farms have a better taste and smell. This was found for apples, cherries and redcurrants. Organic fruits contained more total sugars, which probably influenced the better taste perception by consumers (Rembiałkowska ,2007). From a study we can find that organically grown strawberry has better overall acceptance, flavor, sweetness and appreance than conventionally grown one (Reganold *et al.*,2010)

Table 9. Effect of different organic manures and bio-fertilizers on fruit organoleptic quality of banana cv. Grand Naine (AAA) (1-4 scale basis)

Treatment	Appearance	Flavour	Taste	Overall acceptability
T_1	3.17	2.83	3.27	3.07
T_2	3.25	3.18	3.28	2.67
T_3	3.22	3.16	3.11	3.07
T_4	3.55	3.20	3.80	3.80
T_5	2.67	2.54	3.22	2.80
T_6	3.00	2.97	3.16	3.05
T_7	3.22	2.83	3.28	3.05
T_8	3.07	2.72	3.13	3.10
T_9	3.24	2.61	2.77	3.07
T_{10}	3.33	3.63	3.33	3.13
T_{11}	3.00	2.33	3.00	2.67
T_{12}	2.00	2.16	2.00	2.05

Source: (Hema *et al*., 2016)

Here, T_1: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg); T_2: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (14.20 kg); T_3: FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (2.36 kg); T_4: FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (9.94 kg); T_5: T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop; T_6: AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_7: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop; T_8: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_9: FYM (10 kg)+NC (1.25 kg)+VC (5 kg)+Ash (6.6 kg)+T_{12}+Triple green manuring with sunhemp+cowpea+cowpea as intercrop+AMF (25 g), *Azospirillum* (50 g), PSB (50 g) and *T. harzianum* (50 g); T_{10}: Poultry manure (10 kg)+Neem cake (1.875 kg); T_{11}: 200 g N+50 g P+200 g K; T_{12}: N_0+P_0+K_0

3.4.6. Fruit Antioxidant Properties:

As fruits and vegetables contain antioxidants, eating more of them is linked to a lower risk of developing chronic diseases. Due to the possibility that this type of agricultural management could encourage the synthesis of secondary chemicals like polyphenol, organic foods are believed to have increased antioxidant potential (Faller & Fialho,2010).Organic foods contain 69% higher antioxidants than conventionally grown one (Barański *et al*.,2014). The organic crops contained about one-third higher antioxidant and/or phenolic content than comparable conventional produce. Several studies have found levels of specific vitamins, flavonoids or antioxidants in organic food to be two or three times the level found in matched samples of conventional foods (Benbrook,2005). According to one study, switching to organic versions of common fruits, vegetables, and cereals may increase the amount of antioxidants in your diet. This was similar to adding 1-2 additional servings of fruit and vegetables to your normal diet. (Barański *et al*.,2014). In organic farming higher content of anthocyanins (2027.01, 5620.30 and 7040.97 mg/100 g dry weight DW) were found in raspberries at all maturity stage. Organic fertilization increased the content of flavonoid, phenolic acid and total phenolic compounds at all stages of maturity. Raspberries that were fertilized organically had greater antioxidant capacity values (Fras-Moreno *et al*., 2021). When organic manure combination (50% FYM + 50% Vermicompost + Azotobacter + Pseudomonas) was applied to strawberry plants, fruit quality parameters such as ascorbic acid, total phenolic content, and antioxidant capacity were found to be significantly greater (Negi *et al*,2021).

Table 10. Polyphenols profile (mg/100 g dry weight DW) in raspberry fruits at three maturity stages, pink, ripe, and overripe, grown under organic or conventional fertilization.

Phenolic Compounds Profile	Maturity Stages					
	Pink		Ripe		Over-Ripe	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Total phenolic acid	70.24	64.47	78.16	60.33	78.17	55.72
Total flavonoid	10.77	9.07	6.22	4.31	4.09	3.51
Total anthocyanins	2027.01	900.69	5620.30	3467.26	7040.97	4784.93
Total phenolic compounds	2108.02	974.23	5704.68	3531.90	7123.23	4844.16

Source: (Frías-Moreno *et al*, 2021).

From this table we can see that in organic farming total phenolic acid, total flavonoid, total anthocyanins and total phenolic compounds were significantly higher than conventional one.

3.5. ORGANIC FARMING AND AGRICULTURAL SUSTAINABILITY

Modern agriculture has received global attention in different aspects: (a) increasing demand for food by burgeoning human population; (b) rising risks of agriculture driven global environmental changes; and (c) rising risks of food chain contamination and associated health hazards due to excessive use of agrochemicals. Sustainable agriculture refers to methods of crop and animal management that ensure ongoing ecological productivity while preserving natural resources and promoting human well-being, without causing any harm or damage to these resources. (Seilan , 2020). Sustainable agricultural management practices include maintenance of soil organic matter (e.g., conservation tillage and residue management); selection of crops ecologically adapted to local climate regimes; enhancement of agro-biodiversity (e.g., intercropping and agro-forestry); prevention of soil erosion (e.g., windbreaks and terracing); and strengthening biogeochemical cycles (e.g., efficient crop rotation and adoption of proper irrigation and drainage techniques); and protection of environmental health (e.g., organic farming, integrated pest management, and minimization of use of synthetic fertilizers and biocides). The objective of sustainable development of agriculture is "to increase food and enhance food security in an environmentally sound way so as to contribute to sustainable natural resource management". Therefore, sustainable agriculture has few key indicators; a) Economic viability, b) Social acceptance, c) Ecological safeguard, d) Environmental safety, e) Human and animal wellbeing, f) Technological appropriateness, g) Natural resource base, h) Product quality and quantity, etc.(Binayak, 2019). Fundamentals of Sustainable Agriculture and Rural Development. Organic farming is a kind of composite culture system that fulfills all aspects of sustainable agriculture system.

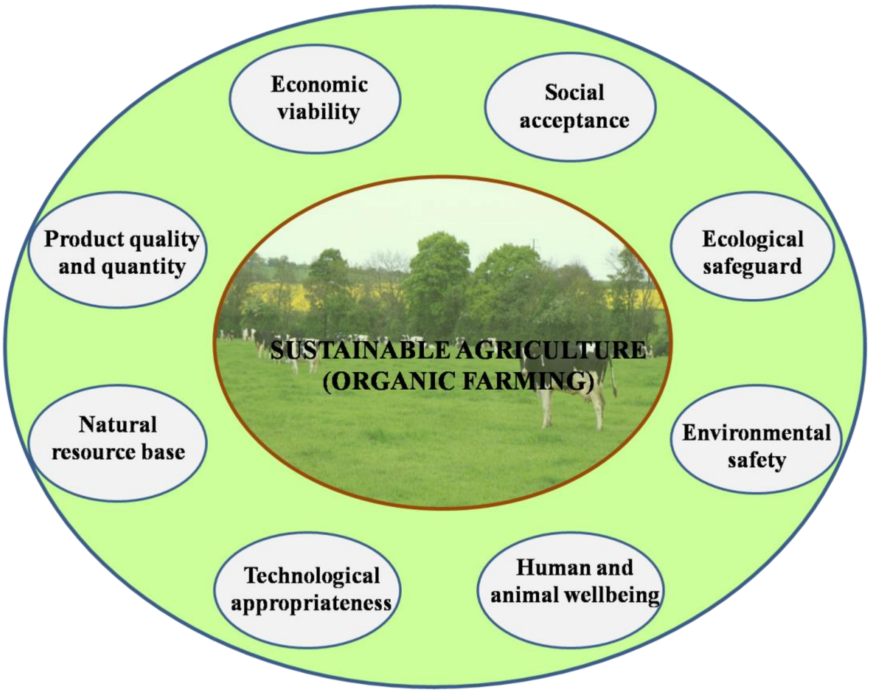

Figure 7. Organic farming approach meeting the aspects of sustainable agriculture system

3.6. CHALLENGES OF ORGANIC FARMING

Despite the invaluable and innumerable ecological and human well beings, there exist some challenges to harvest the paramount blessings from organic farming. These are-

a) Yield gap

Organic food and farming systems generally have lower yields and need more land to produce the same amount of food, which may have negative impacts on the food security. Moreover, lower yields may translate into higher unit costs of production and lower profits for farmers in the absence of price premiums. De Ponti *et al.* (2012) reviewed that organic yields of individual crop are on average 80% of conventional yields but differs somewhat between crops and regions. While, Seufert *et al.* (2012) noted yield differences between organic and conventional farming are highly contextual, depending on system and site characteristics.

b) Economy penalizes diversity

Current policies and markets stimulate the production of single commodities in large quantities that are sold at distortedly low prices at the cost of the environment and humankind. Consolidation of supply and ownership limits farmers' opportunities and can threaten food sovereignty and food security. Limited interests may focus on a limited range of characteristics e.g., convenience, profit, or limited performance characteristics that may prove inadequate or incapable of enduring long term. Reducing the genetic base puts overall gene pool vigor at risk and limits the possible benefits that humans can receive from a wider selection (SOAAN, 2013).

c) Limiting markets and infrastructures

Market development, especially domestic markets, continues to be one of the biggest challenges facing organic agriculture. The primary constraints are the close corner location, remoteness, and isolation from major markets. Lack of supply and a narrow product variety leads to lack of interest by actors throughout the supply chain, inhibiting consumer demand and creating an obstacle to procurement by public and private institutions. Consumer interest could also be restricted due to expensive prices. (Kaellander and Rundgren, 2008)

d) Deficits of standards and policies

Social standards and animal welfare are not consistently codified. In addition, the sensory quality of organic products is not part of the certification. In the absence of regulation on labeling standards for organic production, it is not possible to distinguish an organic product from a conventional product. This has led to fraud practices, and genuine players are not getting the premium, which the consumers of organic products are willing to pay.

e) Insufficient finance against high inputs

With less than one percent of the budget for food and farming systems research spent on organic, there is a lack of funding for basic and applied projects, which hinders development of innovations by scientists and farm advisors (Beintema *et al.*, 2012). The cost of using local or farm-sourced renewable and organic resources such as neem cakes, groundnut cakes, cow dung, and earthworms is increasing compared to using conventional or industrially-produced chemical fertilizers and pesticides. Chemical fertilizers are easier to purchase given the farmer has purchasing power (Wani *et al.*, 2017).

f) Small holding and poor farmers

Most farmers in the tropics as well as other continents are outlined as small holdings and poor. They are not directly connected to markets to buy or sell food (Chandra, 2014; Kaur and Toor, 2015). Since organic farming's main attraction is export, small farmers are less able to compete when the international trade brings down prices even in local markets.

g) Competition

Other sustainability standards compete with organic production, and the multitude of labels causes confusion amongst different stakeholders such as consumers.

CHAPTER IV

CONCLUSION

Organic farming is an effective and promising strategy for sustainable agriculture within a circular and green economy. Its holistic management practices promote the health of the agro-ecosystem, including biodiversity, biological cycles, and soil biological activity. According to the paper's findings, it can be concluded that-

1. Although the land used for organic agriculture worldwide is relatively small, the proportion of organic farms and agricultural land is steadily increasing.
2. Organic nutrient input greatly increases soil nutrient status and yield over control, however in most situations organic output is lower than conventional yield. Organic fruits, on the other hand, are more nutritious, with higher levels of vitamins, minerals, antioxidants, and phenolics; they also have better overall acceptability, flavor, sweetness, and appearance than conventionally farmed fruits.

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