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Organic Farming for Sustainable Agriculture: A Review

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Abstract

Organic farming unites all agricultural systems that maintain ecologically, socially and economically advisable agricultural production. For ensuring sustainable agriculture, organic farming aggregates following practices i.e. optimization of land use and crop structure; efficient use of available organic fertilizing resources; agro-technical methods to protect crops from weeds; crop rotation; soil-protecting technologies for planned chemical land reclamation; preservation of agricultural and biological diversity at farms and its efficient utilization; stabilization of agro-landscapes through uniform system of field-protecting forest belts; facilitation of proper use and preservation of water resources; usage of renewable resources; harmonious balance between crop and animal production through integrated farming and utilization of indigenous technical knowledge. Hence, high-yielding varieties are being used with infusion of irrigation water, fertilizers, or pesticides. This combination of high-yielding production technology has helped the country develop a food surplus as well as contributing to concerns of soil health, environmental pollution, pesticide toxicity, and sustainability of agricultural production. Certified organic products including all varieties of food products including basmati rice, pulses, honey, tea, spices, coffee, oilseeds, fruits, cereals, herbal medicines, and their value-added products are produced in India. Non edible organic products include cotton, garments, cosmetics, functional food products, body care products, and similar products. The production of these organic crops and products is reviewed with regard to sustainable agriculture in northern India. Organic farming provides macronutrients and micronutrients to the plants and also improves soil physical, chemical and biological characteristics of soil.

Keywords: Organic Farming, Sustainable Agriculture, Modern Agriculture

1. Introduction: Organic agriculture is developing rapidly and today at least 170 countries produces organic food commercially. There were 43.1 million hectares of organic agricultural land in India including inConversion areas and with 2 million producers. The world’s organic producers are in Asia (36%), percent followed by Africa (29%) and Europe (17%).

This chapter attempts to bring together, The

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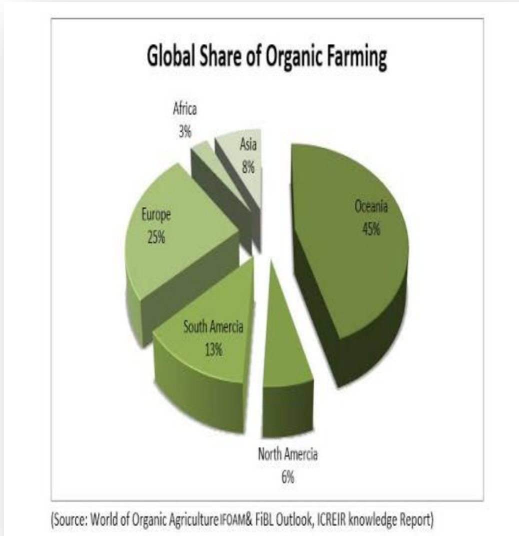

Fig 1: Global share of Organic Farming

Organic movement in India has its origin in the work of Howard. Who formulated and conceptualized most of the views which were later accepted by those people who became active in this movement. Organic farming is a production system which avoids, or largely excludes, the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives. The objectives of environmental, social, and economic sustainability are the basics of organic farming. The key characteristics include protecting the long-term fertility of soils by maintaining organic matter levels, fostering soil biological activity, careful mechanical intervention, nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, effective recycling of organic materials including crop residues and livestock wastes and weed, and diseases and pest control relying primarily on crop rotations, natural predators, diversity, organic manuring, and resistant varieties. A great emphasis is placed to maintain the soil fertility by returning all the wastes to it chiefly through compost to minimize the gap between NPK addition and removal from the soil. Today, the burgeoning population pressure has forced many countries to use chemicals and fertilizers to increase the farm productivity for meeting their ever-increasing food requirements. The prolonged and over usage of chemicals has, however, resulted in human and soil health hazards along with environmental pollution. Farmers in the developed countries are, therefore, being encouraged to convert their existing farms into organic farm The key factors affecting consumer demand for organic food is the health consciousness and the willingness of the public to pay for the high-priced produce. In general, consumers of organic products are an affluent, educated, and health conscious group spurred by strong consumer demand, generous price premium, and concerns about the environment. Because of these hidden benefits, conventional growers are turning to organic farming. In Europe, government policies aim to stimulate the organic sector through subsidies, consumer education, and support in the form of research, education, and marketing. Agricultural practices of India date back to more than 4000 years, and organic farming is very much native to this country. As mentioned in Arthashastra, farmers in the Vedic period possessed a fair knowledge of soil fertility, seed selection, plant protection, sowing seasons, and sustainability of crops in different lands. The farmers of ancient India adhered to the natural laws and this helped in maintaining the soil fertility over a relatively longer period of time [5]. Organic farming is an alternative to regular farming. It makes use of compost, manure, green manure, bone meal rather than using fertilizers and pesticides. This system makes use of organic wastes and crops are raised in such a manner that it keeps the soil healthy and alive. Microbes are used as bio-fertilizers to increase production.

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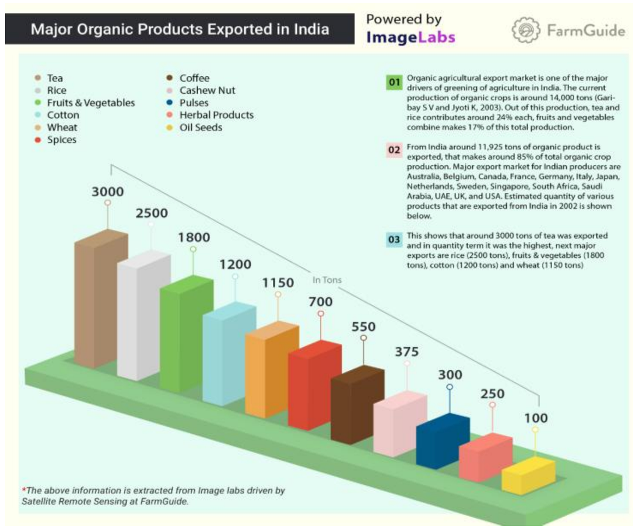

Fig 2: Major Organic Products Exported in India

without polluting the environment. Organic farming promotes eco-friendly agricultural practices without making use of synthetic inputs and majorly relies upon the use of organic wastes to raise crops.

Fig3: Organic Farming, A view

Growing awareness, increasingmarket demand, increasing inclination of farmers to go organic and growing institutional support has resulted into phenomenal growth in total certified area during the last five years. India has also achieved the status of single largest country in terms of total area under certified organic wild harvest collection. With the production of more than 77,000 MT of organic cotton lint India had achieved the status of largest organic cotton grower in the world a year ago, with more than 50% of total world's organic cotton. Agriculture plays a vital role in a developing country like India. Apart from fulfilling the food requirement of the growing Indian population, it also plays a role in improving economy of the country. The Green Revolution technology adoption between 1960 to 2000 has increased wide varieties of agricultural crop yield per hectare which increased 12-13% food supply in developing countries15. Inputs like fertilizers, pesticides

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helped a lot in this regard. But in spite of this fact, food insecurity and poverty still prevails prominently in our country. Uses of chemical biopesticides and fertilizers have caused negative impact on environment and increasing the health problems and many more. India has been traditionally practicing organic agriculture but modern agriculture practices have pushed it to walls. Vermicomposting have positive impacts on plant growth and health and treats organic waste in an environment friendly way.

I. COMPONENTS OF ORGANIC FARMING: Important components of organic farming are biological nitrogen fixation, crop rotation, residues of crops, biopesticides, biogas slurry etc. Vermicomposting has emerged as a major component in organic farming which is very effective in enhancing soil fertility and growth of crops in a sustainable way. The various components of organic farming are**:-**

1. Crop rotation: For practicing sustainable agriculture there should be rotation of crops on the same land over a period of two years or more for maintaining soil fertility and control of insects, weed and diseases. For example use of legumes in rotation improves soil fertility.

2. Crop Residue: India has great potential of using residues ofcrops and straw of cereals and pulses in recycling of nutrients during organic farming. Crop residues when inoculated with fungal species improve physico-chemical properties of soil and crop yields.

3. Organic manure: The organic manure is obtained from biological sources (plant, animal and human residues). Organic manure helps in increasing crop growth directly by improving the uptake of humic substances and indirectly promoting soil productivity by increasing availability of major and minor plant nutrients through soil microorganisms. a) Bulky organic manure: Bulky organic manure includes compost, FYM and green manure having less nutrients in comparison to concentrated organic manure. FYM: - Farm Yard Manure (FYM) refers to the well decomposed combination of dung, urine, farm litter and leftover materials (roughages or fodder). Compost: - Large quantities of waste material (vegetable refuse, weeds, stubble, bhusa, sugarcane trash, Sewage sludge, animal waste, human and industrial refuse) can be converted into compost manure by anaerobic decomposition. Compost is used in the same way as FYM and is good for application to different type of soils and crops. Green Manuring: - Green manuring is practice of adding organic matter to the soil by ploughing and adding into the soil undecomposed green plant tissues for improving physical structure and fertility of the soil. The green manure crop (legume crop) supplies organic matter and additional nitrogen. Commonly used green manure crops are such as Sun hemp (Crotalaria juncea), Dhaincha (Sesbania aculeata), Cowpea, Cluster Bean, Senji (Melilotus parviflor, Vigna sinensis), Berseem (Trifolium alexandrium) etc. b) Concentrated Organic Manure: Oilcakes, blood meal, fishmeal, meat meal and horn and hoof meal (Concentrated organic manures) that are organic in nature made from raw materials of animal or plant origin and contain higher percentage of vital plant nutrients such as nitrogen, phosphorous and potash, as compared to bulky organic manures.

4. Waste:1. Industrial waste: Industrial by products such as spent wash & coir waste can be used as manure. **2. Municipal and Sewage waste:** It is an important component of organic waste**.** **3. Biofertilizers: Biofertilizers;** are microorganisms that have the capability of increasing the fertility of soil for example by fixing atmospheric nitrogen and through mycorrhizal fungi and phosphate solubilisers;These are ecofriendly and sustainable way of achieving soil fertility. Biofertilizers have biological nitrogen fixing organism which help them in establishment and growth of crop plants and

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Fig 4: Organic Farming in India: Organic Farming Methods and Certification

trees, enhance biomass production and grain yields. Types of Biofertilizers: There are two types of bio-fertilizers.

1. Symbiotic Nitrogen-fixation: Rhizobium: Rhizobium Bacteria fixes atmospheric nitrogen in roots of leguminous plants, form tumours like growth known as root nodules. It is widely used biofertilizer which can fix around 100-300 kg N/ha in one crop season.

2. Asymbiotic N-fixation: Blue Green Algae, Azolla, Azotobacter, Mycorrhizae and Azospirillium grow on decomposing soil organic matter and fixes atmospheric nitrogen in suitable soil medium. i) Azotobacter: Azotobactor has beneficial effect on vegetables, millets, cereals, sugarcane and cotton. Organism is capable of producing nitrogen as well as antifungal, antibacterial compounds, siderophores and harmones. ii) Azospirillium: Azospirillium has beneficial effect on oats, barley, maize, sorghum, forage crop and pearl millet. It fixes nitrogen by colonising root zones. iii) Blue Green Algae: Blue-green algae reduce soil alkalinity and it is good for rice cultivation and bio-reclamation of land. iv) Azolla: Small floating fern, Azolla harbours blue-green algae, anabaena, commonly seen in shallow fresh water bodies and in low land fields. They fix nitrogen in association. v) Mycorrhizae: Mycorrhizae is symbiotic association of fungi with roots of Vascular plants. This helps in increasing phosphorous uptake and improve the growth of plants. 6. Bio-pesticide: Biopesticides are of plant origin and include plant products like alkaloids, phenolics, terpenoids and some secondary chemicals. They are biologically active against insects, fungi, nematodes affecting their behaviour and physiology. Commonly known insecticides are Pyrethrum, Nicotine, Neem, Margosa, Rotenone etc.

7. Vermicompost: Vermicompost is organic manure or compost produced by the use of earthworms that generally live in soil, eat organic matter and excrete it in digested form. These are rich in macro and micronutrients, vitamins, growth hormones and immobilized microflora essential for plant growth10. Ii. Effect of inorganic fertilizers and other agro-chemicals on soil and plants Modern agriculture involving use of agrochemicals like fertilizers causes: □ Depletion in soil fertility and pollution problems in ground as well as surface water bodies. □ A portion of the nutrients added through fertilizers does not become available to plants

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and remain in soil which may result in Eutrophication in water bodies like lakes or increase in nitrate concentration in ground water more than the permissible limit of 10 ppm causing Blue baby Syndrome.

Fig 5: Organic Farming: Future of Agriculture

- Increases the soil acidity with nitrification.
- Denitrification results in formation of methane, ammonia, elemental nitrogen and nitrous oxide.
- Depletion of micronutrients like sulphur & zinc. Increased risk of humus depletion and decline in crop production through large doses of N-fertilizers11.
- Trace metal contamination (Fluoride, Arsenic & cadmium) in soils and plants due to large and regular use of phosphatic fertilizers.
- Trace toxic metal contaminants can cause problem when they reach human body through food chain. III. Benefits of organic farming The benefits provided by organic farming are:-

- It maintains health of environment by reducing pollution.
- It helps in increasing agricultural production in a sustainable way.
- It helps in improving the soil health.
- Agriculture productsobtained from organic farming are better in quality. (Bigger in size, flavor, size & aroma)
- Water holding capacity of the soil is increased through organic farming.
- It improves the availability of nutrients required and essential for plants. (Macro nutrients & Micro-nutrients)
- Organic farm products are usually of better size, flavor, aroma (Quality)
- Underground water of the area under organic farming is free of toxic chemicals.
- Vermicomposting brings down waste bulk density.

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Fig 6: Growing of crops under Organic Farming

- Vermicomposting has hormone like substance auxins which increases plant growth.
- Maintains C:N ratio in the soil and increases the fertility and productivity of the soil. Increase in biological activity makes lower depth nutrients availability possible.
- Increases water holding capacity of the soil.
- Improves texture & structure of soil.

Market for organically grown food Consumers concern over high levels of saturated fats, sugarcane, salt in foods as well as the risks from additives and pesticide residues, has stimulated the demand for health foods particularly organic foods. Furthermore, there is an increasing awareness of the environmental damage associated with the use of modern agricultural techniques, especially agrochemicals. At the same time, food surpluses especially in Europe have resulted in encouraging organic farming where in the yield levels are low resulting in reducing the supply. Even though the above factors have contributed to the growth of market for organic food, it is interesting to note that there have been no major promotion campaigns in catering organic food13. However, the media has been relatively sympathetic to organic farming, which has compensated largely for the lack of product promotion through commercial advertising channels. In this context, marketing concepts needs to be prominent but cannot dominate totally. Thus, close attention to marketing is an integral part of successful organic farming. Major problems in marketing indian organic products

- Price expectations are too high in relation to quality
- Low consistency of quality
- Slow shipment, restrictions for importing Indian organic products
- Time consuming and complicated paper work while dealing with export authorities
- The poor customer service from the Indian traders after sales is the major problem in export marketing
- Lack of proper marketing network a marketing implementation
- Less effort to develop domestic markets Scope and modes to promote organic farming As the demand for organic products is increasing over years with people becoming more conscious about the quality of the food stuffs and awareness about the environmental effects due to overuse of chemicals in agriculture. They also opined that if the organic products have a well-defined marketing channel and ensured premium price the likeliness to increases the area under organic farming is wider. When asked for the modes in which organic farming could be promoted the following measures were recommended: Improve the marketing channels
- Ensure premium price for the organic products

- Ensure regular supply of organic manure
- Establish organizations to promote organic farming. Educate people about the benefits of organic farming
- Branding of organic products

Key Features of Organic Farming

1. It makes use of natural microbes as bio-fertilizers to provide crop nutrients [6,7].
2. It makes use of organic wastes to preserve the soil quality.
3. Nitrogen content is maintained using legumes for the process of nitrogen fixation [8-10].
4. Rather than using pesticides to control weed and pests, it makes use of techniques like crop rotation, natural predators, and organic manures.
5. It aims to protect the environment and conserve wildlife.

Methods of Organic Farming

Soil management

Soil is the foundation of terrestrial life. Specific soil management practices are needed to protect and conserve the soil resources. Natural microorganisms such as mycorrhiza form a symbiotic relationship with plant roots and take nutrients from the soil which the plant roots are not able to access to. The act of growing different type of crops in a particular area season after season is known as crop rotation. If same crop is grown every season in a particular area, it will deprive the soil of one particular nutrient but if we will grow different crops every season, it will help in maintaining the nutrient balance of soil. Thus, crop rotation helps in maintaining soil quality. Leguminous plants are also used to increase soil fertility as the fix atmospheric nitrogen with the help of rhizobia bacteria. Addition of manure also enhances soil quality as it contains nutrients such as nitrogen.

Weed management:

Weeds are the undesirable plants that compete with the crop plants. Organic farming promotes weed management in a number of ways . Weed growth is blocked using plastic films and the process is known as mulching. Mowing and cutting removes the top growth of weeds. Grazing is another method which helps in reducing weed growth. Organic crop rotation also promotes weed suppression .

New Revolution in Agriculture

Crop diversity:

In ancient times, the practice of growing only one type of crop was followed. But now-a-days, polyculture is coming in trend i.e. the practice of growing multiple crops within the same place [28-32]. It improves the quality of soil by supporting beneficial soil microorganisms.

Other organisms control:

1. Following methods can be adopted
2. Encourage beneficial predatory insects that feed on pests and helps in controlling them.
3. Make use of organic pesticides and herbicides causing less pollution to the environment.
4. Field sanitization to keep it pest free [38].
5. Growing crops in different location also helps in controlling pests as it disturbs the reproduction cycle of pests.

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Advantages:

1. Unlike conventional farming practices, organic farming does not use expensive chemicals and fertilizers. Thus, it reduces the production costs for farmers .
2. In comparison to conventional methods of farming, organic farming makes use of less fossil fuel by avoiding the use of synthetic fertilizers and helps to slow down global warming .

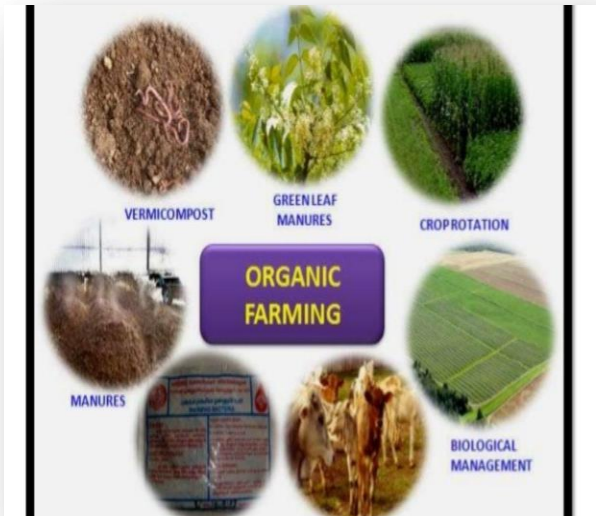

Fig 7: Organic Farming: Different Component

3. The use of chemicals in farming practices causes harm to the environment as the chemicals go deep into the soil and water and contaminate them. But organic farming avoids the use of chemicals and protects the environment from pollution .
4. Fruits and vegetables grown using the practice of organic farming are more nutritious and tasty as they are given the required time to grow and no chemicals are used in their growth.

Disadvantages:

1. Organic food is more expensive than the food grown with conventional farming practices. Therefore, the consumer has to pay more for organic food.
2. Farmer has to work harder if he follows the path of organic farming as this farming practice requires more interaction of farmer with his crop.
3. The practice of organic farming gives the crop enough time to grow without the use of artificial growth injectors. But this practice won't be able to meet the world's demand for food as the organic food takes more time to grow when compared with the conventional practices of growing crops.

Organic farming is a great alternative to conventional farming practices. It follows eco-friendly agricultural practices without making use of harmful chemicals. It helps in maintaining human health as well as protects our environment from harmful chemicals used to raise crops in a field. Going organic is a great way of preventing chemicals and protecting our health and environment but there are a lot of challenges in this field. Due to the high price of organic food, people are not yet accepting the use of organic food . The other challenge in the field of organic farming is to meet the world's demand for food as the growth of organic crops is slow.

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2. Organic Sources of Plant Nutrients:

At present, most optimistic estimates show that about 25–30 percent of nutrient needs of Indian agriculture can be met by various organic sources. Supplementation of entire N through FYM sustains crop productivity at more than use of conventional N fertilizers. Since the estimates of NPK availability from organic sources are based on total nutrient content, efficiency of these sources to meet the nutrient requirement of crops is not as assured as mineral fertilizers, but the joint use of chemical fertilizers along with various organic sources is capable of sustaining higher crop productivity, improving soil quality, and productivity on long-term basis. These organic sources besides supplying N, P, and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate the plants to absorb the nutrients. Application of organic sources encouraged the growth and activity of mycorrhizae and other beneficial organisms in the soil and is also helpful in alleviating the increasing incidence or deficiency of secondary and micronutrients and is capable of sustaining high crop productivity and soil health [6]. The farmers can in turn, get good remuneration from organically produced crops and if included in high value crop rotations, that is, aromatic rice (Oryza sativa L.), table pea (Pisum sativum L.), and onion (Allium cepa L.) due to their heavy demands in domestic, national, and international markets.Nutrient concentrations in FYM are usually small and vary greatly depending upon source, conditions, and duration of storage. The N, P, and K contents of fresh FYM range widely from 0.01 to 1.9 percent on dry weight basis due to variable nature of manure production and storage .Tandon reported that on an average, well-rotted FYM contains 0.5 per cent N, 0.2 per cent P2O5, and 0.5 per cent K2O. Gaur [11] stated that an application of 25 t ha−1 of well-rotted FYM can add 112 kg N, 56 kg P2O5, and 112 kg K2O ha−1. Several researchers all over the world have shown various benefits of the application of FYM on soil properties and productivity of crops. Farmers generally use straw of the harvested crop as animal feed or bedding. In most cases, straw is used as bedding to trap urine to increase N cycling. Wet straw and manures from the animal sheds are collected every day and stored or composted on the farmer's premises. The composted manure is applied either immediately or stored until the next crop season depending upon farmer's socioeconomic conditions. In particular, soil, water, and nutrient management strategies, such as reduced tillage and use of raised beds, that avoid the deleterious effects of puddling on soil structure and fertility, improve water- and nutrient-use efficiencies, and increase crop productivity, may be appropriate .

3. Crop Productivity: Addition of organic matter in the soil is a well-known practice to increase crop yields. Sharma and Mitra reported that the application of organic materials increased grain and straw yield of rice. Ranganathan and Selvaseelan found that application of spent mushroom and rice straw compost though comparable with FYM increased rice grain yields by 20 per cent over NPK fertilizer. Singh et al.reported that the application of 7.5 t FYM ha−1 produced significantly more grain, and straw yields over unfertilized fields. All of the yield attributing characters of rice increased with increasing rates of FYM. Organic farming with dhaincha (Sesbania aculeata L.) made considerable improvement in grain yield of rice and Chickpea .Stockdale et al.narrated the benefits of organic farming to developed nations (environmental protection, biodiversity enhancement, and reduced energy use and CO2 emissions) and to developing countries (sustainable resources use, increased crop yield without over reliance on costly inputs, and environmental and biodiversity protection).Many researchers reported that in an organically managed field activity of earth worm is higher than in inorganic agriculture. In the biodegradation process earthworms and microbes work together and produce vermicompost, which is the worm fecal matter with worm casts. Vermicompost provided macroelements such as N, P, K, Ca, and Mg and microelements such as Fe, Mo, Zn, and Cu [20]. The vermicompost contained 0.74, 0.97, and 0.45 per cent nitrogen, phosphorus, and potassium, respectively.

In low-input agriculture, the crop productivity under organic farming is comparable to that under conventional farming. Tamaki et al.reported that the growth of rice was better under continuous organic farming than with conventional farming. Agroeconomic study of practices of growing maize with compost and liquid manure top dressing in low-potential areas showed significantly better performance than those of current

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conventional farmer practices of a combined application of manure and mineral fertilizers. Maize grain yields were 11–17 per cent higher than those obtained with conventional practices .Productivity of the crop during the initial year in an organically managed field is lower than in subsequent years as soil fertility levels increase over time as organic materials are added in the organic management system [24]. Similarly, Surekha revealed that a gradual increase in grain yield with the use of organic fertilizers over a period of time was observed. Chan et al. [26] showed that the input of organic rice production in three different regions was 46, 25, and 22 per cent higher than conventional rice production, but rice yield was only 55, 94, and 82 per cent of conventional rice production, respectively. However, the cost of lower yield with higher inputs is compensated by the higher premium prices of organically crops in the markets.

Vegetables are highly responsive to organic sources of nutrients and profitable to farmers. Kalembasa reported that vermicompost application of 15 kg per square meter gave the highest yield in tomato crop. Singh et al.studied the response of chilli (Capsicum annuum L.) to vermicompost and observed that the application of vermicompost increased the microbial activities. Vermicompost has a positive effect on the performance of crops due to a higher number of branches and fruits . Tomar et al. recorded the highest yield (97 g plant−1) through vermicompost in brinjal (Solanum melongena L.). Kalembasa and Deska [30] obtained significantly higher yield of sweet pepper (Capsicum annum L. var. grossum) with vermicompost. Reddy et al. recorded maximum plant height at harvest, days to first flowering, and branches plant−1 with the application of vermicompost (10 t ha−1). Similarly, Tomar et al.reported that the application of vermicompost significantly increased leaf area in carrot (Daucus carota L.) plants.Manjarrez et al. conducted an experiment on chili receiving 1.25, 2.0, 3.0, 4.0, 6.0, or 10.0 g of vermicompost kg−1 of soil under greenhouse conditions and reported that the foliar area and photosynthetic rate rose with increasing vermicompost application, and the highest photosynthetic rate (12 mol CO_2 m−2 s−1) was observed with vermicompost at 10 g kg−1 soil. Atiyeh et al. observed that when 20 per cent commercial horticultural medium was replaced by vermicompost there was significant increase in plant height and root and shoot biomass in tomato crop. Ribeiro et al. observed that dry matter content increased with increasing the vermicompost dose upto 400 g kg−1 soil in sweet pepper cv. Nacional Ag. 506. Atiyeh et al. [33] conducted an experiment in which tomatoes were grown in a standard commercial greenhouse container medium (Metro-Mix 360, Manufacturer:

Fig 8: Pros and Cons of Organic Farming

Sun Gro Horticulture Canada Ltd., 770 Silver Street Agawam, MA, USA, 01001), considered as control, substituted with 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 per cent (by volume) pig (Sus scrofa L.) manure vermicompost. They obtained highest marketable yield (5.1 kg per plant) with substitution of Metro-Mix 360 with 20 per cent

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vermicompost. Substitution of Metro-Mix 360 with 10, 20, and 40 per cent vermicompost reduced the proportion of fruit that were nonmarketable and produced more large size (diameter 6.4 cm) than small size (diameter 5.8 cm) fruits. Shreeniwas et al.conducted a field experiment on ridge gourd (Luffa acutangula L. Roxb.) and observed that the increasing levels of vermicompost (0, 5, 10, and 15 t ha−1) increased the fruit weight and fruit volume. Rao and Sankar observed that the effect of organic manure on leaf number, leaf area index, dry matter production, and other growth characters was significantly better than those of inorganic fertilizer in brinjal.Samawat et al.reported that vermicompost had a significant effect on root and fruit weight of tomatoes. In 100 percent vermicomposted treatment, fruit, shoot, and root weights were three, five, and nine times, respectively more than control. Where vermicompost was applied at at 5 t ha−1 or at 10 t ha−1, increased shoot weight and leaf area of pepper plants (Capsicum annuum L.) compared to inorganic fertilizers .

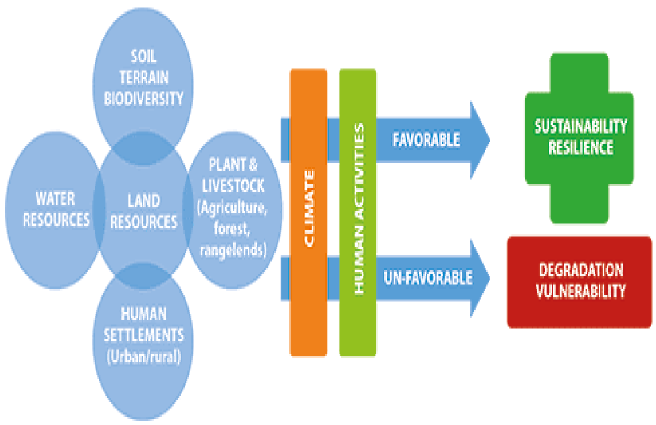

Fig 9: Source: FAO, CLIMATE-SMART AGRICULTURE Sourcebook, Module B.7 Sustainable Soil/Land Management for Climate-Smart Agriculture

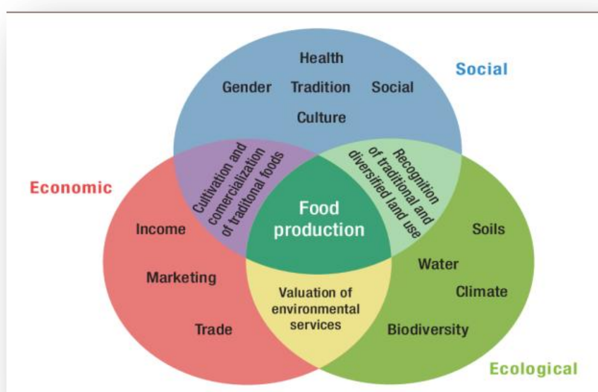

Fig 10: The 3 dimensions of sustainability. (Source: IAASTD, 2009a).

Choudhary et al. obtained the highest yield and available N of tomato cv. S-22 and cabbage (Brassica oleracea L.var. capitata) cv. Golden Acre with vermicompost at 200 g/plant + FYM at 250 g/plant, while maximum K and soil organic carbon was obtained with vermicompost at the rate of 100 g plant−1 + FYM at 500 g plant−1. Hashemimajd et al. [40] revealed that the treatment vermicompost produced from raw dairy manure (RDM) along with some other compost (sewage sludge + rice hull) assimilated higher shoot and root dry matter (DM) of tomatoes than the control (soil + sand).Patil et al. [41] reported that total potato (Solanum tuberosum L.) tubers yield was significantly higher with the application of vermicompost at 4 t ha−1 and FYM at 25 t ha−1. Sawicka et al. [42] reported that the cultivation system had the strongest effect on the share of commercial potato tubers and tubers of a diameter of 4–6 cm in the total yield. Haase et al. [43] suggested that tubers from organic potato cropping may be expected to have sufficiently high tuber dry matter concentrations (19%) for processing into French fries without impairing the texture of the fries when concentration exceeds 23%. Dry matter concentration of tubers for crisps (cv. Marlen) fell short of the required minimum of 22% when a combined N and K fertilizer was applied. Mourao et al. found that organically grown potato cv. Virgo yielded 66% of the conventional crop, whereas Raja yielded 46.6%. The nitrogen uptake of organic crop (tubers and foliage) was 37.0 kg/ha for Raja and 50.5 kg/ha for Virgo compared to that of 21.1% and 27.8% of nitrogen uptake, respectively, with mineral fertilizer.Addition of organic amendments and casting of earthworms to soil also proved effective in controlling diseases in pea (Pisum sativum L.), mustard (Brassica juncea L. Coss.), and chickpea (Cicer arietinum L.) during winter season. Nitrogen, phosphorus, potassium, calcium, and magnesium accumulation also increased with increasing doses of vermicompost as well as with fertilizers . Singh [46] observed that the application of vermicompost at 13–20 q ha−1 increased yield of pea (23.62 q ha−1) and groundnut (Arachis hypogaea L.) (12.16 q ha−1). The principal findings of Jat and Ahlawat revealed that the application of 3 t vermicompost ha−1 to chickpea improved dry matter accumulation, grain yield, and grain protein content in chickpea, soil nitrogen and phosphorus and bacterial count, dry fodder yield of succeeding maize (Zea mays L.), and total nitrogen and phosphorus uptake by the cropping system over no vermicompost. Baswana and Rana [48] reported that the highest pod yield (93.96 q/ha) of pea was recorded when farm yard manure (1 t ha−1) + poultry manure (1 t ha−1) along with mulch treatment was applied followed by farm yard manure (2 t ha−1) + biofertilizers with mulch treatment. Similar trend was also observed for biological yield and harvest index.

Dayal and Agarwal [49] observed that the seed yield of sunflower (Helianthus annus L.) was increased with the higher rate of vermicompost (10 t ha−1); the best combination was 5 t ha−1 vermicompost. Somasundaram et al.reported that the study revealed that increased soluble protein content and nitrogenase activity of maize, sunflower, and green gram (Vigna radiata L.) was estimated with biogas slurry. Increased nitrogen accumulation at all growth stages on maize, sunflower, and green gram was observed under biogas slurry with panchagavya. Higher yield of maize and sunflower was recorded under biogas slurry with panchagavya (a preparation of 5 cow products (dung, urine, milk, ghee and curds)). Silwana et al.reported the importance of organic manure and its long time usefulness in increasing productivity of maize-bean (Phaseolus vulgaris L.) intercrop for small-scale farmers in Eastern Cape of South Africa.

Sangakkara et al.found that the organic matter incorporation increased soil water retention in soil and hence enhanced root growth, culminating in high yields of maize. The impact was greater in maize than in cowpea, especially with gliricidia leaves. Seo and Lee reported that soil organic nitrogen increased considerably by hairy vetch. Dry matter yields of maize increased more in hairy vetch than ammonium nitrate with N rates over 160 kg ha−1. Adiku et al. revealed that the fertilized maize-grass and maize-pigeon pea (Cajanus cajan L. Millspaugh) rotations were identified as those that sustained relatively high maize yields, returned large residue amounts to the soil, and minimized soil carbon loss.

Oliveira et al. reported that the highest average head weight (700 g) and yield (38 t ha−1) in cabbage cv. Matsukaze was produced with the application of earthworm compost at 27 and 29 t ha−1, respectively. Datta et al.confined that the inoculation of seed with Rhizobium leguminosarum bv. phaseoli and incorporation of FYM one week before sowing of rajmash (Phaseolus vulgaris L.) increased yield. Similarly, inoculation of seed enhanced N fixation and incorporation of FYM left a net positive balance of 42 and 84 kg N, respectively, with regards to control (no seed inoculation and no FYM incorporation in soil). A higher accumulation rate of available N at all the growth stage of rajmash was observed with incorporation of FYM and inoculation of seed over control (no seed inoculation and no FYM incorporation in soil).In all four of the years studied, the organic and conventional farming systems did not show significant differences in marketable yields for any vegetable crops, namely, tomato, bean, cabbage, and

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zucchini (Cucurbita pepo L.). The yields in organic farming were 10 per cent and 3 per cent, respectively, higher than conventional farming [57].

Sarangthem and Salam [58] reported that the application of decomposed urban waste with total nitrogen 0.58–1.9 per cent, available phosphorus 0.45–0.67 per cent, and available potash 1.4–1.8 per cent increased the yield of bean to 228 gm/pot from 53 gm/pot. The response on growth and yield of bean (228 g/pot) was recorded higher in the decomposed manure enrich with vermiculture. Renuka and Sankar [59] reported in tomato that the yield increased two and half times with the application of organic manures in comparison with inorganic fertilizer (18.44 tonnes). Likewise, Samawat et al. reported that vermicompost had a significant effect on the number of fruits in tomato. In 100 per cent vermicomposted treatment, fruit numbers were four times more than the control treatment. Arancon et al.reported that when vermicompost applied at 5 t ha^{-1} or 10 t ha^{-1}, the marketable tomato yield in all vermicompost treated plots were considerably greater than yield from the inorganic fertilizer plots. The total and marketable fruit yield of pepper also increased with vermicompost compared with inorganic fertilizers. Thanunathan et al. [60] reported that soil + mine spoil + coir pith vermicompost (1 : 1 : 1) significantly increased plant height, number of leaf, and root length in onion (Allium cepa L.). Lopes et al. [61] reported that the application of vermicompost at 10 t ha^{-1} significantly increased nodulation and dry matter yield of cowpea (Vigna sinensis L.) over its lower levels, namely, 0 and 5 t ha^{-1}. Yadav and Vijayakumari carried out an experiment to assess the effect of vermicomposted vegetable waste on the biochemical characters of chilli and found that the protein was higher at 60 (113 mg g^{-1}) and 90 DAS (79 mg g^{-1}). The carbohydrate content was higher in vermicomposted treatment at 60 DAS (15.34 mg g^{-1}). Chlorophyll (2.61 mg g^{-1}) and total chlorophyll (3.62 mg g^{-1}) contents were observed at 60 DAS, while chlorophyll a (1.01 mg g^{-1}) was higher at 90 DAS as compared to inorganic fertilizers. In another experiment, Haase et al. [43] suggested that tubers from organic potato cropping may be expected to have sufficiently high tuber dry matter concentrations (19 per cent) for processing into French fries without impairing the texture of the fries when concentrations exceed 23 per cent. Similarly, application of FYM at 10 t ha^{-1} alone increased the economic yield and quality parameters like hulling percentage, milling percentage, and protein and amylose content of rice cv. Saket-4 .

4. Quality Parameters of Crops: Mourao et al. [44] found that organically grown potatocv. Virgo yielded 66 per cent of the conventional crop, whereas Raja yielded 47 per cent. The nitrogen uptake of organic crop (tubers and foliage) was 37.0 kg/ha for Raja and 50.5 kg/ha for Virgo, respectively, 21 and 28 per cent of nitrogen uptake by same cultivars grown with mineral fertilizer. Although foliage nitrogen content was increased for the conventional crops, difference between N content of organic and conventional tubers were not significant, as well as for K, Ca, and Mg. Maheswari et al. [64] studied the effect of foliar organic fertilizers on the quality and economics of chilli and observed the highest ascorbic acid content (175.23 mg/100 g) with vermiwash : water at 1 : 5 ratio.

5. Soil Fertility: Minhas and Sood [65] also reported that the organic matter after decomposition release macro- and micronutrients to the soil solution, which becomes available to the plants, resulting in higher uptake. Organic farming was capable of sustaining higher crop productivity and improving soil quality and productivity by manipulating the soil properties on long term basis. It was reported that organic and low-input farming practices after 4 years led to an increase in the organic carbon, soluble phosphorus, exchangeable potassium, and pH and also the reserve pool of stored nutrients and maintained relativity stable EC level. Normal composting takes a long time leading to considerable loss of organic materials as CO2 or does not contribute to the organic pool. Bulluck et al. [69] reported that the use of compost raised soil pH from 6.0 without compost to 6.5 with compost and reduced the broadleaf weed population by 29 per cent and grassy weed population by 78 per cent. Degradation of soil organic matter reduced nutrient supplying capacity, especially, on soils with high initial soil organic matter content in rice-wheat cropping system [70]. Organic farming improved organic matter content and labile status of nutrients [71] and also soil physicochemical properties.

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Fig 9:The impact of the new CAP on organic farming

Addition of carbonaceous materials such as straw, wood, bark, sawdust, or corn cobs helped the composting characteristics of a manure. These materials reduced water content and raised the C : N ratio. However, under Indian conditions, joint composting of the manure slurries with plant residues was more viable and profitable than its separate composting. Use of FYM and green manure maintained high levels of Zn, Fe, Cu, and Mn in rice-wheat rotation. Laxminarayana and Patiram concluded that the decline in soil reaction might be due to organic compounds added to the soil in the form of green as well as root biomass which produced more humus and organic acids on decomposition. Urkurkar et al. reported that supply of 100 per cent nitrogen, that is, 120 kg/ha for rice and 150 kg/ha for potato in a rice-potato cropping system 1/3 each from cow dung manure, neem cake, and composed crop residue appreciably increased the organic carbon (6.3 g kg^{-1}) over initial value (5.8 g kg^{-1}) as compared to supply from inorganic fertilizers alone.However, availability of phosphorus and potassium did not show any perceptible change after completion of five cropping cycles under organic as well as integrated nutrient approaches.

6. Soil Biological Properties: Compost contains bacterial, actinomycetes, and fungi; hence, a fresh supply of humic material not only added microorganisms but also stimulated them . Besides, compost played an important role in control of plant nematodes and in mitigating the effect of pesticides through sorption. Sorption is the most important interaction between soil/organic matter and pesticides and limits degradation as well as transport in soil. Pesticides bound to soil organic matter or clay particles are less mobile, bioavailable but also less accessible to microbial degradation and thus more persistent . Composting material added plenty of carbon and thus increased heterotrophic bacteria and fungi in soil and further increased the activity of soil enzymes responsible for the conversion of unavailable to available form of nutrients. The application of FYM with rhizobium and coinoculation of PSB with rhizobium augmented soybean (Glycine max L. Merr.) production.

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Fig 10: How to Harvest Organic Guava?

Agricultural practices have had an impact on soil biophysiochemical properties. Densities of bacteria, protozoa, nematodes, and arthropods in soils under organic farming were higher than under conventional farming .Bulluck et al.reported that organic fertility amendments enhanced beneficial soil microorganisms, reduced pathogen population, total carbon, and cation exchange capacity, and lowered down bulk densities, thus improved soil quality.

The National Academy of Agricultural Sciences (NAAS) recommended a holistic approach involving integrated nutrient management (INM), integrated pest management (IPM) for enhanced input use efficiency, and adoption of region specific promising cropping systems as an alternative organic farming strategy for India and to begin with the practice of organic farming should value crops like spices, medicinal plants, fruits, and vegetables [83].Singh and Bohra reported that rice-pea-black gram (Vigna mungo L.) cropping system recorded higher population of bacteria, actinomycetes, and fungi than rice-wheat cropping system. Field experiment conducted with P solubilizers like Aspergillus awamori, Pseudomonas striata, and Bacillus polymyxa significantly increased the yield of various crops like wheat, rice, cowpea (Vigna sinensis L.), and so forth in presence of rock phosphate and saved 30 Kg P_2O_5 ha^{-1} with the use of phosphate solubilizing microorganisms. Vegetable crops, in general, responded better to Azotobacter inoculation than other field crops. Nevertheless, yield increase in case of wheat, maize, jowar (Sorghum bicolor L. Moench), cotton (Gossypium spp.), and mustard crop using Azotobacter chrooccocum culture was 0–31 per cent higher than control.In low-input agriculture, the crop productivity under organic farming is comparable to conventional farming. Integrated use of rice straw compost + Azotobacter and PSB was found better than rice straw alone . Azotobacter produced growth promoting substances which improved seed germination and growth with extended root system. It also produced polysaccharides which improved soil aggregation [87]. Seed inoculation of chickpea with rhizobium + PSB (phosphate solubilising bacteria) increased dry matter accumulation, grain yield, and grain protein content in chickpea, dry fodder yield of succeeding maize, and total nitrogen and phosphorus uptake by the cropping system over no inoculation and inoculation with rhizobium alone.

7. Emissions of greenhouse gases:

The climate impact from agriculture in Northern Europe arises mainly from emissions of nitrous oxide (N_2O) from soils, driven largely by N application (44% of GHG emissions from Swedish agriculture), carbon dioxide (CO_2)

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emissions from organic soils (12%), methane (CH4) from enteric fermentation in ruminants (26%) and emissions of N2O and CH4 from manure management (5%) (SBA et al. 2012). Fossil energy use in field machinery and animal housing add to these emissions, but to a lesser extent (10% of GHG emissions). In conventional agriculture, the production of mineral fertilisers is also a considerable source of GHG. Although organic farming does not use energy-demanding mineral fertilisers, the production and transport of some organically acceptable fertilisers require non-negligible amounts of fossil energy input, while GHG emissions can also arise during storage (Spångberg 2014).The yield level is influential when calculating the climate impact per unit product, as the GHG emissions from soils and inputs are distributed over the total output (Röös et al. 2011). Therefore, organic products are frequently assessed as having similar or larger climate impacts per unit product than conventional products, as the lower GHG emissions from avoidance of mineral fertilisers and other inputs are cancelled out by the lower yields (Clark and Tilman 2017). For N2O emissions specifically, Skinner et al. (2014) showed that for yield gaps larger than 17%, N2O emissions are higher for organic products than for conventional products. Hence, there is an opportunity to combine increased yield in organic agriculture with reduced climate impact if yield increases can be achieved with no or low increases in GHG emissions from fields and inputs.Management practices aimed at achieving higher yields by increasing plant nutrient availability, e.g. by reducing N leaching losses using catch crops or manure spreading techniques for reduced ammonia (NH3) emissions, are all beneficial for reducing N2O emissions from soils. Cropping systems and management practices that sequester carbon in soils and standing biomass, e.g. through the use of catch crops (Poeplau and Don 2015), biochar (Kammann et al. 2017) or agroforestry (Fagerholm et al. 2016), can also reduce the climate impacts, while promoting soil fertility and increased crop yields.Increased used of mechanical weeding increases CO2 emissions as a result of fossil fuel combustion. However, the climate impact from farm machinery use is usually a minor part of the climate impact of production (Röös et al. 2011), so the increase in yield from weed control can often compensate climate-wise for the increased fossil fuel use. Apart from reducing GHG losses from organic agriculture, increased use of renewable resources in organic agriculture is in line with organic principles. Biogas production from agricultural residues and/or manure is beneficial from a climate perspective, as it provides renewable energy (Kimming et al. 2015; Siegmeier et al. 2015). Yields can also increase, as the anaerobic digestion process increases the plant availability of N in digestate used as fertiliser. In the future, there will be new opportunities for increasing yields through more intensive machine use without increasing GHG emissions, by a transition to electric machinery in combination with renewable electricity.

8. Nutrient losses: Loss of N and phosphorus (P) from agricultural systems to waterways is a serious problem causing eutrophication, particularly in coastal areas. Agriculture is also the main contributor to airborne NH3 emissions, mainly from manure management (SBA et al. 2012).

Increased inputs of nutrients, especially N, have great potential to increase yields in organic farming (Doltra et al. 2011). However, there is an increased risk of nutrient losses with higher N inputs that needs careful consideration. The risk is greatest when N released from organic fertilisers does not match crop uptake or when N fertilisation rates start to approach or exceed the 'economic optimum level', calculated from known yield response to N mineral fertilisation (Delin and Stenberg 2014). Above the optimum, the yield response ceases and N leaching losses increase exponentially (Fig. 3). Currently, N inputs in organic crop production are often well below the optimum level (SS 2017). Simulations show potential to increase yields through additional use of manure or other organic fertiliser inputs, without negative effects on N leaching (Doltra et al. 2011). Careful management of animal manure to minimise NH3 losses is also crucial, including the use of covers on manure storage facilities and precision spreading. Bandspreading in growing crops and direct incorporation of manure in soils minimises NH3 emissions, increases N use efficiency and raises yield levels (Webb et al. 2013). One of the main sources of N in organic systems is biological N fixation by annual and perennial legumes. The risk of N losses may increase with a large proportion of legumes in the crop rotation, as it is challenging to synchronise timing of N release with crop requirements (Olesen et al. 2009). For example, incorporation of N-rich crop residues in autumn before, e.g. sowing of winter cereals increases the risk of leaching, due to high N mineralisation in autumn often exceeding crop N uptake (Torstensson et al. 2006). Appropriate management practices may reduce such risks. Askegaard et al. (2011),

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Doltra et al. (2011) and Plaza-Bonilla et al. (2015) found potential for catch crops, i.e. crops grown between main crops with the purpose of taking up residual available nutrients, mainly N, in soil, to reduce N losses and release N to the main following crop. In Nordic long-term field trials at different sites, catch crops have improved mean grain yields, corresponding to 0.2–2.4 Mg DM ha^{-1} for spring oats and 0.1–1.5 Mg DM ha^{-1} for spring barley (Doltra and Olesen 2013). Spring tillage on suitable soils is another efficient strategy to decrease N leaching losses during the winter season (SMED 2015). However, on clay soils, in combination with cold conditions early in the growing season, such a measure could reduce N mineralisation rates, negatively affecting crop N availability in spring and early summer and leading to lower yield. Using genetically diverse crops, including intercrops and variety mixtures, that have the potential to perform well under different environmental conditions also minimises the amount of residual available nutrients in the soil (Wolfe et al. 2008).

9. Soil fertility: Agricultural soils are affected by many anthropogenic pressures, such as loss of soil organic carbon (SOC), nutrient depletion, soil compaction and heavy metal deposition (Smith et al. 2016). In Northern Europe, however, the situation is not as severe as in some other parts of the world. In Sweden, cropland topsoils have an average organic matter content of 4% (albeit with high variation), which is considered sufficient to maintain soil fertility for crop production (Eriksson et al. 2010a). A high SOC level is a key characteristic of soil fertility, as it promotes soil structure, aeration, water-holding capacity, chemical buffering capacity, soil microbial activity, plant root development and continuous release of plant nutrients through mineralisation. According to a global review by Gattinger et al. (2012), the results indicated that soils in organic cropping systems have significantly higher levels of SOC than those in conventional systems. Tentative explanations include increased external carbon inputs, organic matter recycling and extended crop rotations with forage legumes in organic systems.Increased yields lead to increased amounts of crop residues being incorporated into soils, raising SOC levels (Diacono and Montemurro 2010). Increasing fertiliser inputs to increase yields reduces the risk of depletion of a range of essential soil nutrients. This is particularly important in organic stockless systems and in systems with small or no external inputs of fertilisers (Watson et al. 2002). Increased use of fertilisers with high nutrient availability, e.g. biogas digestate, or future introduction of renewable mineral fertilisers in organic farming could provide the potential to increase yields through increased precision in fertiliser application. However, such fertilisers may not contribute to SOC building to the same extent as fertilisers rich in organic carbon.

Practices typical of ‘conservation agriculture’, including diversified crop rotations, maximum soil cover and reduced tillage, contribute to reduced soil degradation (Cooper et al. 2016). However, implementation of reduced tillage is limited in organic agriculture, mainly because of the important role of tillage for control of weeds. Shallow inversion tillage at strategic stages in the crop rotation could be a good compromise to ensure both effective weed control and SOC gains (Cooper et al. 2016).A concern for soil fertility associated with spreading of liquid fertilisers, as well as mechanical weeding, is the risk of soil compaction. The development of lighter machinery for mechanical weeding (e.g. self-driving weeding robots), fertiliser spreading through pipelines and processes for reducing the water content in liquid fertilisers will help to reduce this problem.As discussed in Section 3.3, nutrient recycling within the food system needs to be improved to maintain long-term sustainable nutrient supply and there are several promising options (Oelofse et al. 2013). However, urban waste products may contain a number of contaminants, including heavy metals, e.g. Cd, which is of great concern for public health (Åkesson et al. 2014). New techniques are needed for safe recycling systems, e.g. by source separation of sewage (Spångberg 2014). There are also various technologies to recover P from wastewater and sewage sludge by crystallisation or precipitation, with reduced risk of contamination compared with untreated sewage sludge. Treated sewage sludge products may have higher quality concerning contaminants than fertilisers approved in current organic regulations, such as natural phosphate rocks or even animal manures (Wollman and Möller 2015). Closing the nutrient loop is one of the major sustainability challenges for agriculture going forward. However, as current organic regulations hinder the use of many urban waste products, organic agriculture is actually less progressive in this area than conventional agriculture.

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As described in Section 3.2, higher proportions of concentrates in livestock diets to increase livestock yields require more annual cropping, which risks less SOC formation compared with leys (Freibauer et al. 2004). The importance of including clover/grass ley in the crop rotation for preserving carbon stocks in soils is demonstrated in Swedish monitoring datasets by higher organic matter content in soils on dairy farms than on pig farms which mainly grow annual crops (Eriksson et al. 2010a). Consequently, in order to increase yields in production systems with ruminants, increased forage quality through, e.g. optimising ley harvesting times (Nadeau et al. 2015) would be more favourable for promoting soil fertility than introducing higher concentrate proportions.

10. Animal health and welfare:

There have been enormous increases in livestock productivity in recent decades. In Northern Europe, yields in pig production and milk yield per dairy cow have approximately doubled since the 1960s. The division of the domestic hen into egg-laying breeds and meat-producing broiler breeds has increased poultry productivity dramatically (Appleby et al. 2004). However, modern industrialised livestock production systems affect the health and welfare of farm animals in many ways, including health problems related to breeding for high productivity (e.g. leg problems in broilers, high piglet mortality in pork production due to smaller and less vital piglets and mastitis in dairy cows) and limitations on animals expressing their natural behaviour due to being reared in confined and barren environments (e.g. restriction of movement due to crating of sows and the development of injurious behaviours such as tail biting in pork production and feather pecking in poultry) (von Keyserlingk and Hotzel 2015).

Continued breeding for high growth rates, without taking other important breeding traits such as animal health and behaviour into account, and the use of these breeds in organic production risk aggravating current health problems further. For example, there is little or no difference in cow health between organic and conventional dairy systems in Sweden (Fall et al. 2008; Sundberg et al. 2009) due to the small differences in production system, i.e. same breeds and similar yield levels. Hence, Nordic organic dairy systems are among the most high-yielding dairy systems globally, but this comes at a price. Dairy cows commonly suffer from udder health disturbances and locomotion disorders; in 2013/2014, 26% of Swedish dairy cows were treated for some medical condition, although breeding in Sweden combines production, health, fertility and longevity traits into a ‘total merit index’ (Oltenacu and Broom 2010; Rodriguez-Martinez et al. 2008). Joint lesions arise in all pig production systems, but they are more frequent and severe in organic compared with conventional production due to higher stress on pig joints in spacious and outdoor environments, as the leg conformation of modern, fast-growing pigs is not suited to the level of exercise required with large space allowances (Engelsen Etterlin et al. 2015). Hence, it is worth discussing whether still higher yields per animal are desirable and in line with organic principles; attention should perhaps focus on improving animal health and welfare at current production levels or even accepting lower yield per animal if necessary. The development of more suitable breeds should be considered, possibly using or crossbreeding with smaller or indigenous breeds possessing traits favourable for animal health and behaviour in the local environment.However, there are short-term solutions that can be implemented in current organic livestock systems in Northern Europe to improve welfare and increase yields and there are several examples of clear synergies in this area. One example is the use of more suitable breeds that are available internationally today. The use of slower-growing breeds in broiler production could improve animal health and also increase net yield at flock level, due to more appropriate behaviour leading to an increased number of broilers being healthy at slaughter compared with fast-growing breeds (Rezaei et al. 2017; Wallenbeck et al. 2017).

11. Human nutrition and health

It is well known that the input levels of plant nutrients affect plant development and composition (Bindraban et al. 2015; Wiesler 2012), as well as crop yields. To some degree, yield and nutritional quality may be divergent breeding goals (Morris and Sands 2006), since historically, the breeding and production of high-yielding varieties has led to a decreasing content of certain minerals in some vegetable and cereal crops (Marles 2017).The production system, organic or conventional, generally has no or only a small effect on the concentrations of most nutrients and secondary metabolites in crops. The exception to this is phenolic compounds, where various meta-analyses report an overall modestly higher concentration (14–26%) of total phenolics in organic crops (Mie et al. 2017). Increased N fertilisation has a negative effect on the concentration of phenolic compounds in crops (Treutter 2010). Phenolic compounds from plant sources are believed to carry benefits for human health, although this is not fully understood (Del Rio et al. 2012). Based on current knowledge, it is not possible to derive any specific health benefit from the slightly higher concentration of phenolic compounds in organic crops. Accordingly, increasing yields in organic farming by increasing crop fertilisation is not expected to lead to nutritionally relevant effects on crop composition.In a 2-year controlled field trial examining the composition of white cabbage using untargeted metabolomics, measuring approximately 1600 compounds, researchers were able to discriminate between cabbage from organic and conventional production, but not between cabbage from one low-input and one high-input organic system (Mie et al. 2014). Therefore, intensifying organic crop production within the range of current organic fertilisation practices is not expected to lead to major changes in plant composition.

The use of chemical pesticides is strongly restricted in organic production. Limited data indicate that toxicity-weighted human dietary pesticide exposure from organic foods in Sweden is far lower than exposure from conventional foods (Beckman 2015), and the associated health risks are small. However, 10 compounds with some type of identified human toxicity are currently approved in organic crop production in the EU (Mie et al. 2017), and increased inputs of these compounds, which are likely to lead to increased human exposure, are per se undesirable. Conversely, increased inputs in the form of 'basic substances' are regarded to be of low concern for human health (Marchand 2015). Likewise, the use of microorganisms, macroorganisms or habitat manipulation in plant protection is not associated with any known risks for humans.

12. Farm profitability: The profitability in organic production varies considerably between products, regions and farms. However, many studies have concluded that organic farms are frequently more profitable than conventional farms due to higher price premiums, government support and/or lower costs (Nemes 2009). In a recent meta-analysis, Crowder and Reganold (2015) found that without price premiums organic farming would be significantly less profitable than conventional agriculture due to 10–18% lower yields, showing the importance of price premiums for profitability in organic farming. For the farmer, the economic effect of increased yields in organic agriculture will depend on how the revenues of the farming business are affected, including how consumers respond to such changes and the costs associated with achieving increased yields.

The profitability of organic farming hence strongly depends on consumers being willing to pay a price premium. Crowder and Reganold (2015) found that a premium of 5–7% is required in order for the profits in organic farming to equal to those in conventional farming, while the actual premium is around 30%. Reasons for buying organic food include health and nutritional concerns, perceived superior taste, environmental and animal welfare concerns and distrust in conventional food production (Hoffmann and Wivstad 2015). Although higher yields per se do not necessarily affect demand, a change towards more intense practices in organic farming, making it more similar to conventional farming in some respects e.g. by increased use of fertilisers and concentrate feeds, may negatively affect the premium some consumers are willing to pay for organic food (Adams and Salois 2010). Furthermore, increased yields would presumably lead to a larger supply of organic products, which if not matched with a corresponding increase in consumer demand would result in a reduction in prices. In countries where organic production receives government support, another potential risk to farm revenues of increasing yields is that it may be used as an argument for removing subsidies.Improving productivity generally requires investment in additional capital (e.g. machinery or additional land) and/or labour (e.g. increased mechanical weeding) which may increase the financial risk of the farmer. Hence, increased yields may not be preferred by all farmers, although some studies have found organic farmers to be less risk-averse than conventional farmers (Gardebroek 2006) and intensification may reduce the yield variation.Variations in yield, and hence in economic returns, between organic farms have been partly explained by differences in management and marketing skills. Experience and knowledge influence farmer behaviour. For example, a flexible approach to crop rotations on organic farms in Sweden has been found to be positively correlated to the experience of the farmer (Chongtham et al. 2016). Knowledge transfer between farmers is important in improving management skills and the ability of farmers to apply best available management practices. Yield increases which depend on investments in costly specialist machinery (e.g. for mechanical weed control) may create incentives for more extensive cooperation in sharing machines. Adoption of new technologies is becoming easier and less costly as the technology becomes more widespread. Thus, more widespread uptake of good organic practices will promote yield increases (Läpple and van Rensburg 2011). This stresses the importance of effective communication channels for knowledge sharing and transfer in improving yields and productivity in organic farming.

13. CONCLUSIONS: Organic farming is the system of farming that promotes environmentally, socially andeconomically sound products of food and fibers. As the awareness about the harmful effect of chemicals on health, soil, environment etc., is increasing; that's why inorganic farming is shifting its way towards organic farming. India with diverse agro climatic conditions has great potential for organic farming and many products are produced organically in India. High price for organic products and lack of proper marketing functions within domestic markets are the major constraints in organic farming in India.

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