UNIT 12 INTEGRATED FARMING SYSTEMS

Structure

12.1 INTRODUCTION

Over the last three decades, green revolution technologies have enabled India and other countries of the South Asian region to attain self sufficiency in food production. Advantage was taken of the high yielding varieties of grain and the existing irrigation potential was exploited. As a result the production and productivity have increased several folds. If fast growth in agricultural production has to be maintained to feed the growing populations of this region, then the new challenges that arise as a result of the very factors that have ushered the green revolution, have to be met appropriately.

Recent years have witnessed a rapidly growing concern about the quality of life and natural resources and in the earlier unit you read about the interrelationships between the resources needed for food production and for maintaining an environment congenial for the health of humans and other life forms. You also learnt about the integration of traditional knowledge, modern tools and techniques, and innovations in resource management.

In this unit we will discuss integrated farming systems, their components, and the need for their development for leading the region to meet the food security challenges coming ahead. Integrated farming systems may comprise more than one farm enterprises (viz. crops, dairying, poultry, beekeeping, fisheries, agro forestry mushroom cultivation etc.)/subsystems on a farm to harness maximum efficiencies and obtain sustainable resources use systems which will optimize their use minimize degradation and induce regeneration capacity as well as increase overall productivity, income and employment. This needs intensive cooperation between the various agricultural sectors that could contribute to the sustainability of the region's broad base agriculture.

You will also learn about the role of integrated farming systems in avoiding risk due to environment constraints and providing farmers a basket of multiple choices comprising alternate but matching enterprises for fulfilling household needs. In this unit we also devote a section to discuss the concept and need for organic agriculture as an alternative to the current unsustainable agricultural practices in the South Asian region.

Objectives

After studying this unit, you should be able to:

- discuss the concept and various components of integrated farming systems;
- explain the role of integrated farming system in sustaining overall agricultural production;
- state the effectiveness of integrated farming systems in supplementing the farm family income;
- state the future possibilities of integrated farming systems in providing food security in the region;
- explain the need and benefits/advantages/constraints of organic farming;
- suggest more efficient use of external inputs in farming systems; and
- exchange and discuss various strategies and experiences concerning integrated and organic farming systems.

12.2 FARMING SYSTEM

Farming system represents an appropriate combination of farm enterprises like cropping systems, livestock, poultry, fisheries, forestry and the means available to the farmer to raise them for increasing productivity and profitability. What kind of a farming system a farmer adopts and what suits the farmer's resources are of prime importance to sustain the natural resources, farm income and meet the diversified demands of the growing population for food, fodder, fibre and fuel.

12.2.1 Concept and Components

Farming has been divided into disciplines viz. crop production, dairy, husbandry etc., each being the domain of different subject specialists. However, farmers are not specialists; they regard farming as a whole and this whole is more than the sum of the parts seen by the subject specialists. Moreover, farming is not just a collection of crops and animals to which certain inputs are applied and immediate results are available. Rather ,it is a complicated network of soil, plants, anim als, implements, workers, other inputs and environmental influences with the reins held and manipulated by the farmer, who given his or her preferences and aspirations, attempts to produce output from the inputs and technology available.

The term **farming system** refers to a particular arrangement of farming enterprises that are managed in response to the physical, biological and socioeconomic environments and in accordance with the farmer's goal, preference and resources. A farming system can be viewed as a system in which the farm household is the basic unit that focuses on:

i) the interdependencies between the various components under the control of the farm household members and

ii) how these components interact with the physical, biological and economical factors not under the control of the household.

Components of the farming systems are the individual pieces that make up the system of concern. Almost every component is a system in itself with multiple components at a smaller scale, and it plays its specific role in relation to the system as a whole. Farming systems can be characterized according to their biophysical and human setting:

Biophysical setting The genetic resources, techniques and strategies chosen by farmers to develop and maintain their farming system, depend on their ecological conditions. Farmers generally depend on their local resources to the greatest extent

possible but many physical (climate and soil) and biological (pests and diseases) factors may limit the farming options.

Human setting: Farming systems are determined by regional, socioeconomic, cultural, and political characteristics. Each farm household provides the management, knowledge, labour, capital and land for farming and consumes at least a part of the produce. The household thus is a centre of resource allocation, management, production and consumption. Certain factors may also limit the farming options like, availability of land, labour or capital, or market demands, transport facilities and human skills.

The aim of farming systems is to integrate farm enterprises for optimum utilization of resources, minimize environmental damage, increase the farmer's income, create employment opportunities throughout the year, increase export potential and support agro-industry and food security.

A sustainable agricultural farming system aims at improving agricultural production while conserving the regenerative capacity of the natural resource base. It combines traditional ecological understanding and results of modern scientific research on natural processes. It is thus maximizing use of knowledge of natural processes. Sustainable farming systems include both organic and integrated agricultural systems.

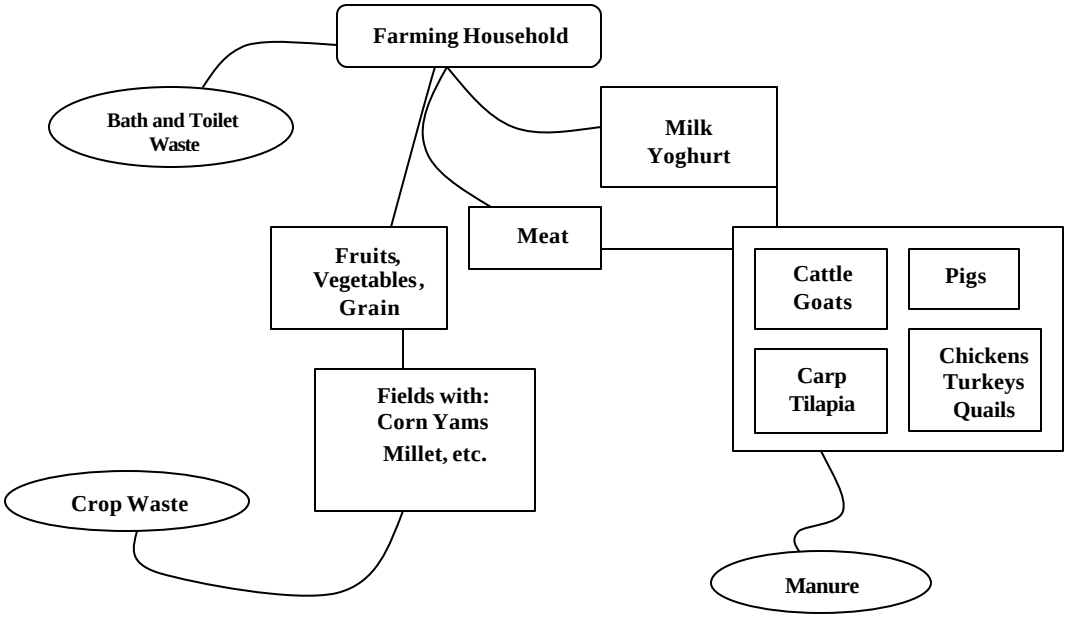
12.2.2 Integrated Farming

In view of the geometric rise in the population of the South Asian region and shrinkage of agricultural land and operational holdings in the post green revolution era, farmers have to include some more enterprises like animal husbandry, bee keeping, fisheries, piggery etc., apart from cropping systems to augment their income and conserve the natural resources and to attain food security. Farmers feel the need to shift from low profit field crop farming system to a diversified multi- enterprise farming system. The traditional mixed or **integrated farming system, (IFS)** which had been less productive, but ecologically more sustainable, is coming back.

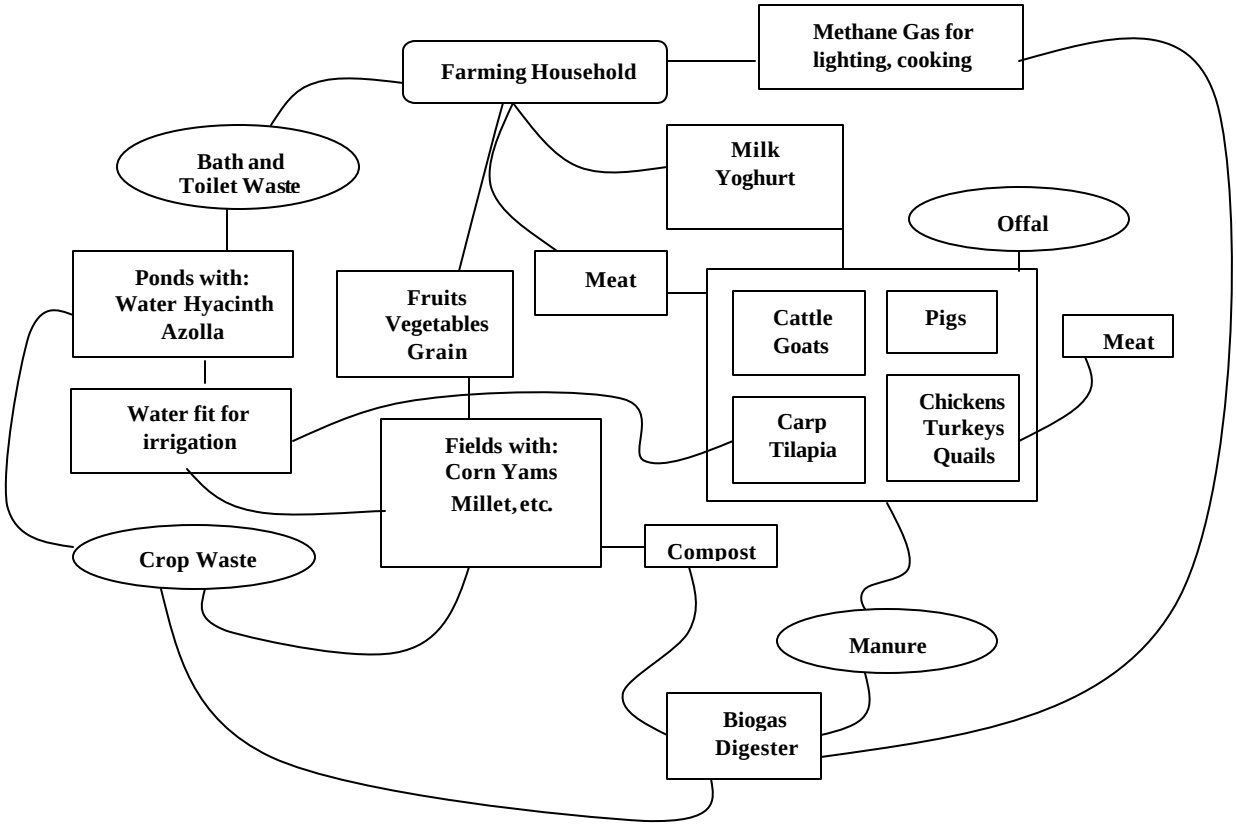
The integrated farming system aims at a sustainable, highly-productive, socially desired mixed farm. This will be reached by minimizing the nitrogen supply and biocide use per unit produce while maintaining high yields and product quality. This aim is characteristic for the so-called globally-oriented agriculture where high productivity and efficiency are combined by making maximal use of the biological mechanisms that dictate the functioning of these agricultural systems. This type of agriculture does not exclude particular inputs such as fertilizers and biocides, but maximizes their efficiency and effectively at the global scale. It is based on lower external inputs and a (more) natural crop protection system than conventional farming.

Thus integrated farming is particularly useful for developing countries, as it requires minimal inputs in terms of expensive chemicals or technology. This has a core component of the most dependable farming system, for instance field crop, around which other complementary farming systems, like livestock/aquaculture/ beekeeping/mushroom culture/poultry/ agro forestry etc., are integrated for obtaining maximum productivity, profitability and sustainability. An integrated farming system could comprise agri- livestock or agri- livestock- poultry, or agri-horticulture-silviculture, etc. By using the by-products or wastes of one component as inputs to another, such farming systems are able to increase the net efficiency of the entire system and at the same time minimize overall waste production and reduce dependency on industrially derived external inputs. Figure 12.1 shows the material flow in a conventional farming system and an integrated farming system. However, before an integrated farming system is designed, 'the farmers' needs, financial implications, opportunities available and the socio-economic conditions and marketing facilities of the region are to be kept in mind. At the same time one has to

be aware of the changes taking place in regional, national and international agricultural scenarios and in environmental parameters.



Conventional Farming System



Integrated Farming System

Fig.12.1: Comparison of material flow in a conventional farming system and an integrated farming system.

The farming system should be fully integrated in order to use the locally available alternate resources. For example, in Asian countries, in a system consisting of livestock as one of the components, animal manure is an important source of fuel. It is estimated that out of the world's population 8 to 12% depend on manure for heating and cooking. Animal manure is a valuable fertiliser too and forms a link between crop cultivation and animal production systems throughout the developing world. At the same time, manure can be put to good use through biogas production and cultivation of earthworms. Biogas is probably the cheapest source of energy for the rural areas of developing countries. Its production would not only save fuel wood, it would also be beneficial for integrated farming systems by providing alternative to fertiliser for crops, fish and water plants (Fig 12.2). Other benefits would be reduction of smells and elimination of smoke during cooking and destruction of pathogens, thereby improving the farm environment.

The beneficiaries of the use of local resources in integrated farming systems are the farm families; in particular the women as they are the one to collect the firewood an activity that can be largely replaced by biogas when livestock are confined and local feed resources are also used in the bio-digesters. Thus the role of livestock in farming systems is multifaceted and must be seen as contributing to the total farming system and not only as a primary form of production of meat, milk etc.

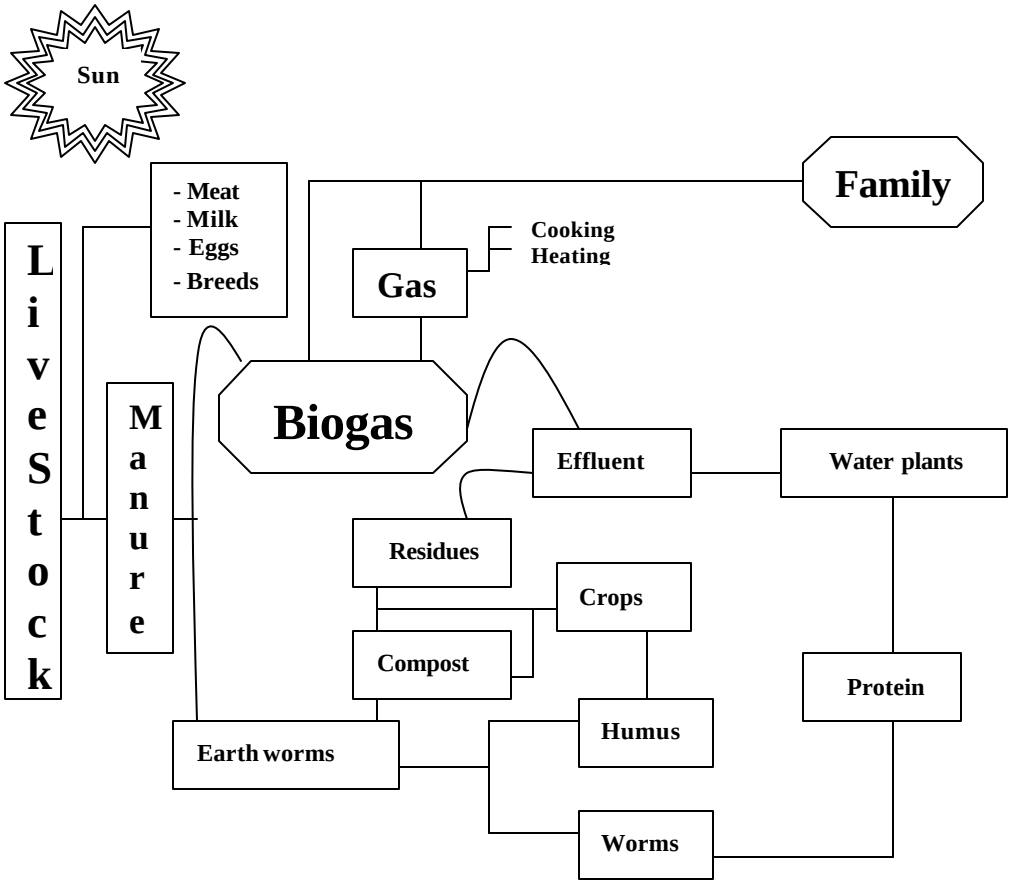


Fig.12.2: Integration of livestock and crop cultivation making maximum use of the manure

Integrated poultry-fish farming is practiced in many countries of the world, and especially in Asia. It is not only an efficient way of recycling farm wastes but also produces high economic returns Studies have revealed that livestock manure is an important source of nutrients for fish cultivated in ponds. In India, the production of poultry birds with fish resulted in fish production of 4,500 to 5000 kg/ha. Chicken manure is considered a complete fertiliser as it has the characteristics of both organic as well as inorganic fertiliser, and fish culture in an integrated poultry- fish system, uses free manure as a pond fertiliser. Raising poultry over fish ponds has a number of

benefits for the south Asian region viz. i) chicken houses constructed over ponds do not have to compete for land needed for other purposes in a region where growing populations is reducing the area of land available for farming; ii) hygienic conditions are better in chicken houses constructed over ponds, as the excreta falls directly in to the ponds; and iii) chicken excreta provides food and fertiliser for fish culture.

A field experiment conducted in wetlands of Coimbatore, Tamil Nadu using various combinations of cropping, poultry, pigeon, goat and fisheries enterprises revealed that integration of crop with fish, poultry, pigeon and goat rearing resulted in higher productivity than cropping alone (Table 12.1). Crop+ fish+ goat integration recorded highest economic returns (Rs 493/ ha/ day) in comparison to cropping alone (Rs. 167/ha/day) The employment opportunity also increased to 570 man days for the whole year by integrating crop+fish+goat as against 369 man days/ year of cropping alone. The system as a whole made use of produce or waste material of one component as input for another component at almost no cost to the farm. Therefore, there is a possibility of reduction in production cost in the integrated farming system. Also combining cropping with other enterprises increased labour requirement and provided more opportunities to employ family labour round the year.

Table 12.1: Component and system productivity of different integrated farming systems

(Mean over two years 1998-2000)

Farming Systems Productivity (Kg/ha)	Component Productivity (Kg)					System
	Crop	Poultry	Pigeon	Fish	Goat	
Cropping alone	12223	–	–	–	–	12223
Crop + Fish + Poultry	29166	630	–	2063	–	31859
Crop + Fish + Pigeon	27973	–	2592	1790	–	32355
Crop + Fish + Goat	28809	–	–	1983	8818	39610

Farmers in the South Asian region have been raising crops and livestock together for centuries (see Fig. 12.3). For them livestock has been an integral part of the farming system, however, promotion and support for widespread adoption of productive, remunerative, ecofriendly and self sustaining integrated farming system is a significant challenge.

Fig. 12.3: Integrated fish and cattle farm

In agricultural enterprises, small and marginal landholders have to face different problems than large landholders, since they have to depend on farming for most of their household needs and such farmers are poor with resource constraints and with low educational qualifications. The benefits of most agricultural technologies remain confined to the large farm holders. Therefore, it is necessary to develop suitable technologies for small landholders for whom the concept of integrated farming system is better than specialized or single component based farming system.

Integrated farming systems have the following advantages:

- **Increased food supply:** Vegetable or horticulture crops can provide 2 to 3 times more calories than cereal crops on the same piece of land. Also if beekeeping, mushroom growing, silviculture and aquaculture are integrated in a multi-tier system, they can give additional food and increase without affecting the production of food grain crops.
- **Recycling of crop residue:** For instance in India, more than 200 metric tonne residue produced per annum. If one percent of this is used for mushroom cultivation then the production would grow several folds. Good vermin compost can also be produced from crop residue for restoring the soil fertility. Cost of production is reduced.
- **Use of marginal and waste land:** Marginal and wastelands can be efficiently used for a combination of fisheries, poultry, dairying, mushroom cultivation and bee keeping with crop raising.
- **Increased employment:** Studies conducted on integrated farming systems in India show that adoption of crop+fisheries+ livestock on arable land can give three times more gainful employment than crop alone. If other farm enterprises like silviculture, beekeeping and mushroom cultivation are also adopted, they can provide greater income and gainful employment to farm families to increase their standard of living.
- **Restoration of soil fertility and conservation of the environment:** With efficient recycling of crop residue and farm waste in crop- livestock- poultry- fishery system, soil fertility can be restored. It will also reduce the dependence on chemical fertilizers and a cleaner environment can be maintained.

In material as well as social terms, integrated farming can affect human development in the following ways:

- It can make farmers more self-sufficient as well as self-reliant. There is a substantial generation of knowledge and innovations because of the different systems involved.
- Poor and landless farmers can be assisted to generate income and thus participate in the development process.
- External inputs needed in the system are minimized. It also provides for better utilization and distribution of labour. Costs are generally reduced and productivity of labour is increased.
- In areas where farmers face problems of land fragmentation, integrated farming has the potential for giving opportunities for productive activities.
- By appreciating that women contribute far more to household security, integrated farming will go a long way in improving the condition and welfare of women.

Therefore, there is a general improvement in the sustainability of the system, creating more wealth on a more equitable and environmentally friendly basis.

Thus, integrated farming system approach is not only a reliable way of obtaining fairly high productivity with substantial fertilizer economy, but also a concept of ecological soundness leading to sustainable agriculture.

Box 12.1: Resource optimizing in coffee and cardamom based faming system: A case study

Robusta coffee and cardamom are perennial crops and can be grown together for efficient utilization of natural resources. An experiment was conducted for nine crop seasons (1985 to 1994) of a monoculture of coffee and mixed crop of coffee and cardamom. The net returns in mixed cropping were 4.06 times more than mono cropping. Bee keeping can also help the small and marginal farmers growing cardamom as the natural forest flora offers abundant pollen and nectar for honeybees. Indian honeybee (*Apis cerea Fab)* is the principal pollinator of cardamom flowers. The small farmer can keep 25-30 beehives and earn a profit of approximately Rs. 20,000 per year.

Similarly scientific piggery using exotic varieties like Yorkshire, Hampshire and landrace in the high ranges of the western ghats, has been found to gain faster growth rates, better feed conversion and higher yields. These pigs can be fed concentrated feed as well as kitchen waste, garbage, green fodder and aquatic weeds. Long term study showed that a commercial piggery unit with 250 piglets resulted in a net profit of Rs 7, 17,900 over a period of 12 years. Since there is a great demand for pork in the Western Ghats, hence piggery offers a good scope for organic recycling of farm waste and high returns for the farmers.

Water harvested in the farm pond would normally be used for irrigating the plantation crops. Using intensive fish culture known as composite fish culture which uses several indigenous varieties like catla, rohu, mrigal and exotic varieties like carp, grass carp and silver carp can offer better yields and profits than conventional fish culture in the farm ponds. This kind of intensive mixed farming can not only increase the overall productivity and economic returns but also help the farmer in effective utilization of natural resources.

SAQ 1

What are the elements of integrated farming?

12.3 ORGANIC FARMING

Organic farming is a method in which land is cultivated or crops raised in such a way so as to avoid or exclude the use of synthetic inputs like fertilizers, pesticides, hormones, antibiotics, feed additives etc; and to largely rely on crop rotations, crop residues, animal manure, farm waste and other biological material along with beneficial microbes for release of nutrients and plant protection. As per FAO definition, **organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion to all off-farm inputs**.

The concept of organic farming is not new to the countries of the South Asian region. The traditional agricultural practices followed from ancient times in the region have evolved through centuries to create agricultural systems adapted to local environmental and cultural conditions. Owing to their nature, traditional systems do not use synthetic agricultural inputs and many if not all traditional systems fully meet the criteria for organic agriculture. But over time, the use of inorganic fertilizers,

chemical pesticides and other synthetic inputs has led to enormous levels of chemical buildup in our environment, in soil, water, air, in animals and even in our own bodies. Fertilisers have a short-term effect on productivity but a longer-term negative effect on the environment where they remain for years after leaching and running off, contaminating ground water and water bodies. The use of hybrid seeds and the practice of monoculture has led to a severe threat to local and indigenous varieties, whose germplasm can be lost for ever. This has led to the renewal of interest in the age old practice of organic farming to ensure uncontaminated food production as well as keep the land in a healthy condition. The primary goal of organic farming is to ensure optimum health and productivity of interdependent communities of soil life, plants, animals and people. Even though organic agriculture cannot ensure that products are completely free of residues, methods are used to minimize pollution from soil, air and water.

It is also being realized increasingly that 'Green Revolution' involving technologies such as mechanization, intensive irrigation, improved seeds, synthetic fertilizers and pesticides has reached a plateau, and is now sustained with even higher inputs and is giving diminishing returns. In the name of growing more to feed the earth, we have taken the path of unsustainability. The effects already show - farmers committing suicide in growing numbers with every passing year; the horrendous effects of pesticide sprays (endosulphan) by a government-owned plantation in Kerala, (India) some years ago; the pesticide-contaminated bottled water and aerated beverages are only some instances.

The bigger picture that rarely makes news however is that millions of people are still underfed. Developing countries that traditionally have had a net surplus in agricultural trade have to depend on food imports. The present food production model ties farmers into conditions of dependence on large corporations who buy agricultural inputs in terms of seed, fertilizers, and pesticides and to sell their produce. Another negative effect of this trend has been on the fortunes of the farming communities worldwide. Despite this so-called increased productivity, farmers practically in every country around the world, have seen a downturn in their fortunes. The only beneficiaries of this new outlook towards food and agriculture seem to be the agro-chemical companies, seed companies and – though not related to the chemicalisation of agriculture, but equally part of the "big money syndrome" responsible for the farmers' troubles – the large, multi-national companies that trade in food, especially food grains.

In the present conditions to attain food self reliance, agriculture in the region would have to depend on local resource management without having to rely on external inputs. This would involve substituting purchased goods by knowledge of natural processes that optimize competition for nutrients and space within the agri-ecosystem. Organic farming has the capability to take care of each of these problems. Besides, the obvious immediate and positive effects, organic or natural farming has on the environment and quality of food, it also greatly helps a farmer to become self-sufficient in his requirements for agro-inputs and reduce the investments on farming costs. Thus organic agriculture offers a means to address food self- reliance, rural development and conservation of biodiversity, and natural resources.

12.3.1 Steps of Organic Farming

Organic agriculture is the most regulated form of ecological agriculture though it is not limited to certified organic farms and products alone, but includes all productive agricultural systems that use natural processes rather than external inputs to enhance agricultural productivity. Agriculture that meets the organic criteria but is not subject to inspection, certification and labelling is referred to as non-certified organic agriculture as distinguished from certified organic agriculture. However, both rely on the same technology and principles but an organic farm reflects an intentional management system according to organic principles. Non- certified organic

agriculture therefore includes the traditional farming systems following ecological approaches to enhance their production without the use of chemicals.

The techniques and practices integral to organic farming may be adapted and made suitable to the surrounding of the farmers. Organic farming requires that the answers to a problem should come from the farmer, his fields and his surroundings rather than from a chemical factory or the pesticide shop. Moreover, there cannot be a fixed package of practices - every area is unique in its own way, has its own endemic species - both plant and animal - and its own natural conditions, problems and solutions.

1. **Conversion of land from conventional management to organic management**.

   In the case of a chemical farm converting to organic however, there is often a loss in yield and it takes a few years before yields increase and stabilize at a level often higher than that achieved under a chemical regime. It is therefore, recommended to convert gradually over a period of three to four years to obtain full organic status if income from the farm is a key issue. If the land was under exploitative cropping that is, arable cropping, with crops other than legumes, before the beginning of conversion then some fertility building crop like grasses and legumes must be planted.

2. **Crop production with the use of alternate sources of nutrients**

   Building of soil fertility is the cornerstone of organic agriculture. Organic practices create suitable conditions for soil biota and abiotic resources through manipulation of crop rotations, green manuring, reduced tillage and organic fertilisation (animal manure, crop residue, green manuring, compost etc,). Let us look at some of these alternate methods of increasing the nutrient content of soil.

- **Crop residues**

  Huge quantity of crop wastes/residues and animal wastes are always available on a farm. The common practice is to burn plant wastes which, besides being an environmental disaster, are also a waste of the huge potential. Properly recycled, these residues form excellent compost in one to six months, depending upon the composting process used. Every farm can choose or even develop a suitable compost process depending upon its own needs and resources, including availability of labour, managerial time and investment potential (Fig.12.4).

Fig.12.4: Composting pit (Photo courtesy Vikas Chadha, Satavic Farm)

One method of composting farm wastes is by **vermi-composting**, which uses earthworms to eat and break up the organic wastes. There are a number of other methods innovations, adaptations and improvements which always possible. Methods can be aerobic or anaerobic and above ground or below, though the best way to get high quality compost quickly is to make a heap above the ground.

Composts can be fortified using various natural additives and enriched/improved by using effective micro-organism preparations.

- **Mulching**

  Mulching is the use of organic materials to cover the soil, especially around plants to keep down evaporation and water loss. Besides this, mulching adds valuable nutrients to the soil as they decompose. Mulching is a regular process and does require some labour and plenty of organic material, but has excellent effects, including encouraging the growth of soil fauna such as earthworms, preventing soil erosion to some extent and controlling weed.

- **Green Manuring**

  This is an age-old practice prevalent since ancient times. A crop like dhaincha (*Sesbania aculeata*), sunhemp or horsebean or a mix of all three is sown (usually) just before the monsoons. Around flowering (30-45 days after sowing), the crop is cut down and mixed into the soil after which the season's main crop is sown. Green manuring is beneficial in two ways - firstly it fixes nitrogen, and secondly the addition of biomass (around five to ten tons/hectare) greatly helps in improving the soil texture and water holding capacity. Green leaf manuring can also be carried out if sufficient leguminous tree leaves are available.

- **Cover cropping**

  Cover cropping is normally carried out also with nitrogen-fixing crops that grow fast and require little or no inputs like water or additional manuring. While cover crops can yield some returns, they are mostly used for covering the soil in the fallow months, adding nitrogen to the soil, suppressing weeds, preventing soil erosion and later used as biomass or fodder. Velvet bean is an example, and it finds use as a fodder crop and biomass generator. Another useful cover crop is *Dolichos lablab* which is a source of fodder and food.

- **Crop Rotation and Polyculture**

  One of the most important aspects of organic farming is the strict avoidance of monoculture, whether annuals or perennials as monoculture systems are unhealthy for the ecosystem of which they are a part. Traditional farmers till date follow the systems of crop rotation, multi-cropping, inter-cropping and polyculture to make maximum use of all inputs available to them, including soil, water and light, at a minimum cost to the environment.

  Crop rotation is the sequence of cropping where two dissimilar type of crops follow each other For example, cereals and legumes, deep-rooted and short-rooted plants and where the second crop can make use of the manuring or irrigation provided some months earlier to the first crop (e.g. rice + wheat, rice + cotton). The combinations possible are endless, and will depend to a great deal on the local situations.

  Multi-cropping or mixed cropping is the simultaneous cultivation of two or more crops in a year. In Indian agricultural tradition, farmers have been known to sow as many as 15 types of crops at one time. An example of multi-cropping is Tomatoes + Onions + Marigold (where the marigolds repel some of tomato's pests). Fig. 12.5 shows a cropping system of coconut and banana.

  Inter-cropping is the cultivation of another crop in the spaces available between two rows of the main crop. A good example is the multi-tier system of coconut + banana + pineapple/ginger/leguminous fodder/medicinal or aromatic plants. While ensuring bio-diversity within a farm, inter-cropping also allows for maximum use of resources.

The concept of polyculture should not be limited to plants only but extended to cover the whole farm. This way, one system's wastes and by-products are another system's inputs, or one system is comprised of more than one component, which allows for efficient use of available resources.

Fig.12.5: A cropping system of coconut and banana. A mid- storey and a ground crop can also be introduced to make it a truly integrated cropping system

An example of such integration is: rice-fish/prawn systems (Fig. 12.6) where the fish/prawn mature in the waterlogged fields and are harvested before the water drains away (making use of available resources). They have a symbiotic relationship with the main crop in two ways – manuring and pest control.

Fig.12 6: The fish pond shown in the picture is part of an integrated farm where all inputs except fish seed is sourced from the farm it self. Organic practices have increased the yield in comparison to neighbouring farms (Photo: courtesy website of Satavic farms).

A larger and more permanent example of integrated multi enterprise farming system could be: annual crops + tree crops + dairy cows + honey bees.

The animals and tree crops are benefited by the honey bees (pollination); crop residues and tree pruning are useful as cattle feed and green leaf manure, dung from the cattle are used for bio-gas production, after which the slurry finds use in the fields as manure and in the compost heap. As you have read in the earlier section, there is no limit to the diversity of integration that is possible on a farm.

- **Microbial biofertilisers**

These are biologically active (living or temporarily inert) inputs and contain one or more types of beneficial micro-organisms such as bacteria, algae or fungi. Every microorganism – and hence each type of bio fertiliser – has a specific capability and function.

There are broadly seven types of bio fertilisers:

1) Rhizobia is a group of bacteria that fixes nitrogen in association with the roots of leguminous crops. Rhizobia can fix 40-120 kgs. of nitrogen per hectare annually depending upon the crop, *Rhizobium* species and environmental conditions. They help improve soil fertility, plant nutrition and plant growth and have no negative effect on soil or the environment. Every leguminous crop requires a specific *Rhizobium* species.

2) *Azotobacter* is also a group of nitrogen-fixing bacteria but unlike rhizobia, they do not form root nodules or associate with leguminous crops. They are free-living nitrogen fixers and can be used for all types of upland crops but cannot survive in wetland conditions. In soils of poor fertility and organic matter, *Azotobacter* needs to be regularly applied. In addition to nitrogen-fixation, they also produce beneficial growth substances and beneficial antibiotics that help control root diseases.

3) *Azospirillum* species also do not form root nodules or associate with leguminous crops. They are however not free-living and live inside plant roots where they fix nitrogen, and can be used in wetland conditions. This group of micro organisms also produces beneficial substances for plant growth, besides fixing atmospheric nitrogen. *Azospirillum* does well in soils with organic matter and adequate moisture content, and requires a pH level of above 6.0.

4) Blue-green algae or Cyanobacteria are free-living nitrogen-fixing photosynthetic algae that are found in wet and marshy conditions. They are easily prepared on the farm but can be used only for rice cultivation when the field is flooded.

5) *Azolla* is a free-floating water fern that fixes nitrogen in association with a specific species of cyanobacteria. *Azolla* is a renewable bio fertiliser and can be mass-produced on the farm like blue-green algae. It is a good source of nitrogen and on decomposition, a source of various micronutrients as well. Its ability to multiply fast, means it can control weeds in (flooded) rice fields. *Azolla* is also used as a green manure and a high-quality feed for cattle and poultry.

6) Phosphate solubilizing organisms are a group of bacteria and fungi capable of breaking down insoluble phosphates to make them available to crops. Their importance lies in the fact that barely a third of phosphorous in the soil is actually available to the crop as the rest is insoluble. They require sufficient organic matter in the soil to be of any great benefit.

7) Mycorrhiza is a sweeping term for a number of species of fungi which form a symbiotic association with the plant root system. Of these, the most important in agriculture is vesicular-arbuscular mycorrhiza or VAM. Plants with VAM colonies are capable of higher uptake of soil nutrients and water. VAM strands act as root extensions and bring up water and nutrients from lateral and vertical distances where the plant root system does not reach.

- **Reduced Tillage**

Reduced tillage or conservation tillage is a practice of minimising soil disturbance and allowing crop residue or stubble to remain on the ground instead of being thrown away or incorporated into the soil. Reduced tillage practices may progress from reducing the number of tillage passes to stopping tillage completely (zero tillage).

Reduced tillage is important from the viewpoint of organic farming too. The cover of crop residue helps prevent soil erosion by water and air, thus conserving valuable top soil. Soil structure improves because heavy machinery (which causes soil compaction) is not used and soil tilth is not tampered. With earthworms not being disturbed, their numbers increase bringing with them the accompanying benefits of better soil aeration and improved soil fertility. Microbial activity in soil also increases for the same reason.

3. **Non-chemical Management of Weeds and Pests**

In a well-managed organic farming system, pests and weeds are considered to be part of the system itself as they do not usually get out of control. Many organic farmers believe, and perhaps rightly so, that any pesticide, should not be used. Where prophylactics do not work, and pest populations reach proportions where economic loss is a surety, there are a number of non-chemical methods of pest control. These include:

1) Picking off the pest by hand (where the pest is a large caterpillar for example),
2) Use of pheromone traps,
3) Use of light traps (for moths and other insects),
4) Use of predator species,
5) Growing trap crops (e.g. Mustard with cabbage; Maize around cotton),
6) Use of microbial pesticides and biological agents like *Heliothis, Spodoptera*, *Trichogramma*, *Trichoderma*, etc.,
7) Using easily-prepared natural pesticides.

For preparing natural bio-pesticides, a number of plants can be used. Neem, ginger, chillies, *Vitex negundo* (Indian pivet tree), custard apple (the seeds), *Pongamia pinnata* (pongam/karanj), asafoetida, turmeric, garlic, tobacco, sweet flag, *Nux vomica*, tulsi and Persian lilac are among the many plants that are commonly used in pest control. Each pest requires a specific preparation.

12.3.2 Organic Farming Scenario

Organic farming is a fast growing segment of agriculture world wide. The total area under organic management is shown in Fig. 12.7.and the total number of organic farms in each continent is shown in Fig. 12.8. Organic food products like fruits and vegetables are becoming more popular in the foreign markets like USA, Europe and Japan and get sold at a higher price than conventional food products. World trade in organic products was estimated at 17.5 billion dollars in 2000 and is growing significantly in European countries, USA and Japan and at present the demand outpaces the supply. Amongst all nations of the world, Austria and Denmark lead in consumption of organic foods. The average consumption of organic food in EU and USA is approximately $15 per capita per year.

The recognition of the role of organic agriculture in achieving environmental objectives including sustainable use of land, led to the adoption of agri-environmental measures to encourage organic agriculture. Consumers in the North concerned with food quality, as well as protection of the environment were the first to initiate a demand for organically produced food products. The crisis over dioxin contaminated food and livestock diseases such as foot and mouth disease and Bovine Spongiform Encephalopathy (BSE) further increased the demand for organic foods.

These concerns have also opened markets for export from developing countries especially in the south Asian region enhancing their foreign exchange earnings and diversified exports. Price premiums of about 10-50 percent over non-organic products can help to tide over the expense incurred in switching over to organic approaches. Many countries offer good export opportunities for supply of organic foods not grown domestically for instance coffee, tea, cocoa, spices, sugar-cane, tropical fruits and beverages as well as off season fresh produce.

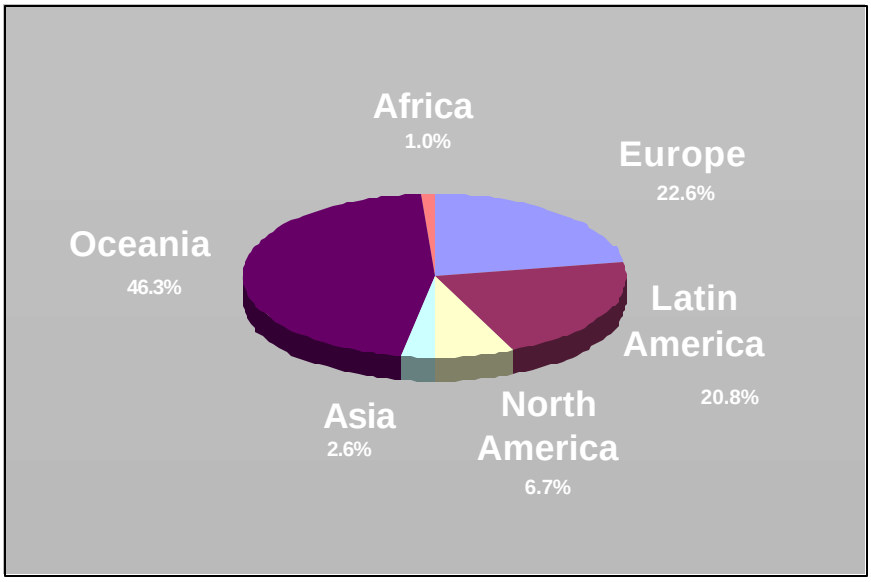


Fig.12.7: Share of each continent in the total area under organic management.

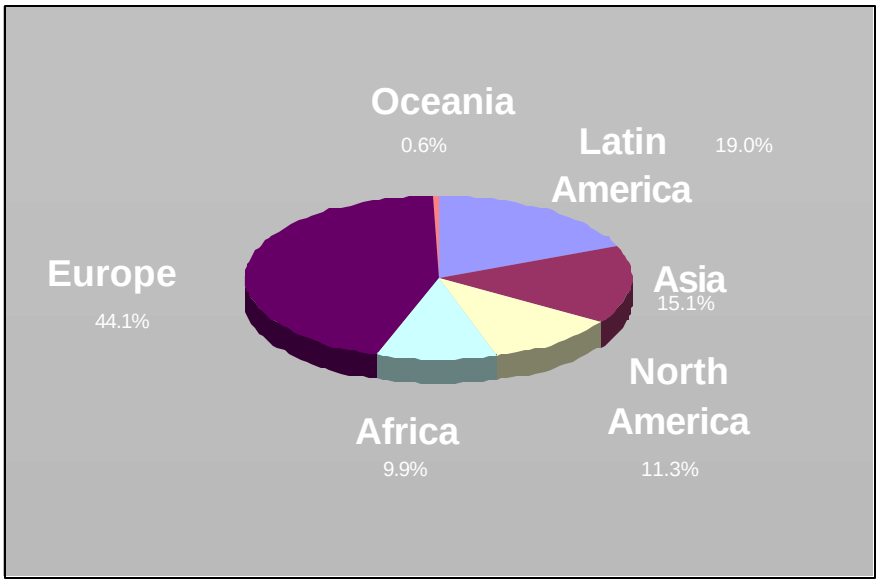


Fig.12.8: Total number of organic farms, share for each continent.

12.3.3 Organic Agriculture in India

In a study conducted by Food and Agriculture Organisation (FAO) in mid-2003, India has 1,426 certified organic farms supplying approximately 14,000 tons of organic food / produce annually. But the fact is that there are a number of farms in India which have either never been chemically-managed / cultivated or have converted back to organic farming because of their farmers' beliefs or purely for economic reasons. These farms use crop residues, manures, legumes and neem to grow their crops and rely on crop rotation and interplanting to do their job.

Although the products grown under these systems are not defined as organic products, they are by all means genuinely organic. Their produce either sells in the open market along with conventionally grown produce at the same price or sells purely on goodwill and trust as organic through select outlets and regular specialist bazaars. These farmers will never opt for certification because of the costs involved as well as the extensive documentation that is required. Now it is high time that these products are

classified accordingly and the farmers get a premium on their produce. This will also go a long way to alleviate their poverty and raise the standard of living.

There are a number of farmers that grow organic vegetables, fruits, plantation crops, spices and tea organically and export it to Germany and Netherlands. Usually farmers associated with big export houses do not have to bother about the sale of their products or about certification, it is the small and marginal farmers that face the difficulties.

Organic Sugar Cane Cultivation in Belgaum, Karnataka, India – Case Study

The organic farmer's club in Belgaum, Karnataka has 400 members, some of whom are already growing organic crops, while others are in the process of converting to organic farming. One of its founding members- Suresh Desai has been caring for the family property of 4.5 hectares of sugar cane growing farmland.

Conventionally sugar cane is grown in a three year cycle. The crop takes about 18 months to mature, after which it is cut and the ratoon crop is left to grow. After cutting the cane the remaining trash in the field is either used as roofing material or burned in the field. This burning releases the nutrient in the trash as well as helps to eliminate the pests in the field. However the nutrients in the ashes are leached out after the first irrigation and Desai's yield was like other farmers of the region about 70to 90 tons per hectare. With escalating prices of external inputs he realized that he could stop and even reverse the process of degeneration in his fields. With this realization began his experiments that ultimately changed his sugarcane cultivation practices.

At first he tried composting his crop residue to fertilize his crops but that involved additional labour and time. This brought him to his second step in which he tried leaving the residue in the fields that produced them. With this method Suresh was able to reduce the application of chemical fertilizer by 50 percent while maintaining the same productivity. But irrigation related problems started appearing and he tried mulching to prevent evaporation losses and with this he devised another way of irrigating his fields- the two in one irrigation system. In this system he kept the trash in one row and made water channels in the second row. By connecting the two parallel irrigation rows with perpendicular trenches at the ends he was able to water his fields more easily. Thus, Suresh Desai was able to reduce the irrigation requirement and after harvesting the cane he put the trash in the rows that were used previously as water channels.

After three years Suresh observed a remarkable improvement in soil and increase in soil life. After using green manure between the rows of cane he found that there was no need to use chemical fertilizers. He also found his crops healthy thus, eliminating the use of chemical pesticides.

Furthermore, because of the healthy condition of his fields Suresh has stopped ploughing or turning his field. The only soil work left is the periodic maintenance of the irrigation channels.

Ever since ploughing of the field has stopped, the water retention capacity of the soil has increased and frequency of irrigation has decreased from once in 10 or 12 days to 20-25 days. In this way the water usage has reduced to 75-80 percent in comparison to conventional usage.

Soil fertility in Suresh's field is maintained by the combined effect of:

- Reduced irrigation by which salt build up is minimized and nutrient leaching is prevented.

- Trash composting which prevents evaporation of moisture from the soil, improves the soil structure and quality and as the trash decomposes it provides nutrients back to the roots.
- Green manuring which is a source of nitrogen and other elements, thus compensating for the high carbon content of trash and according to him also combats the effects of continuous mono-cropping without rotation.
- Soil conditioning that hastens the decomposition of trash by enhancing the proliferation of fungi.

The benefits of Suresh's methods are:

- His canes mature in 8 or 8.5 months in comparison to 11 or 12 months of the conventional farming system.
- Sugar recovery is better than the chemically grown ones.
- His canes are healthy with no smut or grassy shoot and no chemicals or botanical sprays have been needed.
- Suresh's cane yield is 100tons in comparison to his fellow farmers whose yield is 110 tons but then his investments are much less in comparison to that by his fellow farmers.
- He claims that water requirement is even less than that required through sprinkler irrigation.
- As minimum tillage is practiced there is no fallow or replanting of sugarcane. Thus labour cost is significantly reduced.
- Since he used the natural biological cycles as the main input, there was an impressive increase in soil biodiversity, which is now maintaining the yields.
- The use of traditional dry farming crops as green manure, functions as a gene pool for the rapidly disappearing species.
- Suresh has been able to reduce the costs per hectare, mainly due to decrease in labour requirement. As he uses few external inputs investment is low and his yields are average, but his net profits are higher than those of a conventional farmer.

More and more farmers are following Suresh's model of sugarcane cultivation and some have obtained even better results than Suresh himself! Through out his experimentation Suresh has learnt a variety of lessons, all of which are fundamental to organic agriculture, and the sustainable use of natural resources. His experiments have shown that a diverse soil biodiversity is a powerful tool for organic agriculture and can substitute external inputs entirely (*Source* FAO).

12.3.4 Benefits of Organic Farming

Organic farming differs from other farming systems in a number of ways:

- It favours renewable resources and recycling of wastes so that nutrients are returned to the soil. A succession of micro-organisms (bacteria, fungi, detritus feeding invertebrates) occurs in the detritus, until organic matter is reduced to elemental nutrients.
- It generates only non-accumulative and biodegradable waste and by-products.

- Organic farmers build upon the environmental services and help to enhance soil fertility. Soil structure is improved through nutrient mining by deep rooted crops, improvement of nutrient availability through mycorrhizal associations, crop rotation crop residues green manures etc. Minimum tillage favours carbon retention in the soil and avoids soil compaction. Integrating trees and shrubs conserves water and provides defence against adverse weather conditions. Due to change in soil structure and increased organic content of the soil in organic management, water efficiency is likely to be high on organic farms.
- It respects the environment's own system for controlling pests and disease in raising crops and livestock and avoids synthetic pesticides, herbicides, chemical fertilizers, growth hormones antibiotics and gene manipulation.
- It helps in maintaining environmental health by reducing pollution and reduces health hazards due to absence of residues in the agricultural products.
- It promotes and enhances agro-ecosystem health, biodiversity, genetic heterogeneity, biological cycles and soil biological activity.
- It reduces cost of agricultural production in terms of energy use. In organic farms, mechanisation is often replaced by labour, especially for weeding and harvesting of diversified crops. Indirectly, substituting natural for synthetic fertilizers saves non-renewable energy and nitrogen leaching is minimized.
- Diversification of crops and livestock varieties on organic farms means that risks are spread. There may be less chance of a bumper year for all enterprises but then there is less chance of low production in all crops and livestock simultaneously. This contributes to food security and stability of supply.
- Although yields in organic farms are less than yields of intensive-input conventional farms, they are still within acceptable limits and experiences of low productivity agro-ecosystems show potential to double or triple average yields.
- Organic farming and integrated farming also represent real opportunities for contributing to vibrant rural economies through sustainable development.

Nevertheless, organic farmers face huge uncertainties. The constraints in adoption of organic farming practices by farmers are often the high managerial costs and risks of shifting to a non chemical way of farming, limited awareness and lack of marketing infrastructure, inability to capture marketing economies and limited access to capital.. Lack of information is a major obstacle to organic conversion. Most people in all kinds of areas including scientists, researchers, extension officers and politicians strongly believe that organic agriculture will not be able to contribute to food security.

Let us now examine the linkages between organic agriculture and biodiversity in the next section.

SAQ 3

List the three most important issues in your opinion that are related to organic agriculture.

12.4 ORGANIC AGRICULTURE-BIODIVERSITY LINKAGES

Organic agriculture offers a means to address food self-reliance, rural development and conservation of nature. The common thread in all this is the sustainable use of biodiversity. Successful organic agriculture needs appropriate functional groups of species and essential ecosystem processes as its main input to compensate for the restriction on the use of synthetic inputs of fertilizers and plant protection chemicals is

imminent. In fact, a close relationship exists between organic agriculture and biodiversity conservation. A natural ecological balance between below and above ground is the key to success in organic agricultural systems.

Therefore, an organically healthy soil is the base for food production and a diversity of plants and animals on land prevents pests and diseases.

- Organically managed soils significantly increase biological activity and total density of soil micro-organisms. Such biodiversity improves nutrient cycling and soil structure.
- Organically managed soils have an abundance of earthworms and other beneficial arthropods living above the ground and this improves the condition of crops. The biomass of earthworms in organically managed soils is 30-40 percent higher than in conventional systems. More abundant predators help to keep the pests in check.
- Organic crops benefit from root symbionts (see section 12.3 too). On an average mycorrhizal colonization of roots is highest in crops unfertilized grown under organic systems. Conventional crops have 30 percent lower colonization levels.
- Organic soils have higher micro-organisms that mineralize more actively and also contribute to stable soil organic matter and thus nutrients are recycled faster and soil structure is improved.
- Enzyme activity in organic soils is much higher than in conventionally managed agro-ecosystems
- Wild flora including endangered species is more abundant in organic fields. Weeds often sowed in strips in inorganic fields to reduce the incidence of aphids, influence the diversity of arthropods. Flowering weeds are useful in attracting pollinators and parasitoids.
- Organic agriculture has a closed nutrient cycling on the farm and therefore, has high energy efficiency.

There are several hundreds of small and marginal farmers in the South Asian region who still follow the traditional system of agriculture which promotes the use of local varieties or breeds of live stock that are better adapted to local conditions. Besides the fact that organic farmers cannot use synthetic inputs, their use of organic fertilizers and natural pesticides are uneconomical in the long run. Therefore, the comparative advantage of certain local varieties that are able to withstand local natural stress, especially in marginal lands makes organic farmers adopt biodiversity management as an important productive strategy.

In addition large pool of genetic resources for food can be maintained and other useful organisms such as predators, pollinators and soil micro-organisms are increased. Thus organic farmers are providing an important contribution to the *in situ* conservation, restoration and maintenance of agricultural biodiversity and conserve and improve the natural environment.

12.5 SUMMARY

In this unit you have learnt that:

- Farming System is a concept that puts together the components of soils, water, crops and cropping systems, livestock, labour, capital, energy, and other resources with the farm family at the focal point, thus aids in integrated management of agriculture and other related events.

- The main concept of integrated farming system is that the farm consists of subsystems which all work together in a synergistic manner, one subsystem creating inputs for the other and eventually ending in a more closed cycle. It is based on the fact that since resources are finite and so they must be used judiciously to bring about a positive change in the economic and social framework of the people.

- Integrated farming involves the utilization of locally available resources that may involve feeds, wastes and other outputs from the subsystems within. There is a high degree of nutrient cycling and reduction of energy cost. This holistic approach in total farming system helps in reduction of waste and creating interdependence and overall economic efficiency. Thus the system is more sustainable ecologically, economically and socially.

- Organic agriculture is an earth friendly system that promotes biological cycles and soil biological activity. It is based on minimal off- farm inputs and on farm management practices that restore and maintain ecological balance and harmony. All kinds of agricultural products like grain, eggs, poultry, meat, fibres, cotton etc can be produced organically without the use of synthetic fertilizers and pesticides.

- Organic agriculture seeks to optimize the primary efficiency of agro-ecosystems, keeping the local environmental conditions and social needs of a region in mind. It makes use of many more varieties of plants and animals than conventional system of agriculture. Thus organic farmers are providing an important contribution to the *in situ* conservation, restoration and maintenance of natural resources including agricultural biodiversity.

12.6 TERMINAL QUESTIONS

1. Explain what a farming system is. How is an integrated farming system different from organic farming system?
2. What constitutes organic agricultural system?
3. How do organic farmers fertilize their crops? How do they control crop pests and weeds?

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