

**M. S. SWAMINATHAN SCHOOL OF  
AGRICULTURE**

**Department of Agronomy**

**Farming Systems and Organic Farming for Sustainable  
Agriculture**

**ASAG3207**



**Centurion**  
**UNIVERSITY**

*Shaping Lives... Empowering Communities...*

| Lecture no | Topics                                                                                                                                              |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| 1          | Farming System-scope, importance, and concept                                                                                                       |
| 2          | Types and systems of farming system and factors affecting types of farming                                                                          |
| 3 & 4      | Farming system components and their maintenance                                                                                                     |
| 5          | Cropping system and pattern, multiple cropping system, Efficient cropping system and their evaluation                                               |
| 6,7 & 8    | Allied enterprises and their importance                                                                                                             |
| 9          | Tools for determining production and efficiencies in cropping and farming system                                                                    |
| 10         | Sustainable agriculture-problems and its impact on agriculture Indicators of sustainability, adaptation and mitigation                              |
| 11         | Conservation agriculture strategies in agriculture                                                                                                  |
| 12         | HEIA, LEIA and LEISA and its techniques for sustainability                                                                                          |
| 13         | Integrated farming system-historical background, objectives and characteristics, components of IFS and its advantages                               |
| 14         | Site specific development of IFS model for different agro-climatic zones                                                                            |
| 15 & 16    | Resource use efficiency and optimization techniques, Resource cycling and flow of energy in different farming system farming system and environment |
| 17 & 18    | Organic farming, principles and its scope in India                                                                                                  |
| 19         | Initiatives taken by Government (central/state), NGOs and other organizations for promotion of organic agriculture                                  |
| 20         | Organic ecosystem and their concepts                                                                                                                |
| 21,22 & 23 | Organic nutrient resources and its fortification and Restrictions to nutrient use in organic farming                                                |
| 24         | Choice of crops and varieties in organic farming                                                                                                    |
| 25 & 26    | Fundamentals of pest and disease management under organic mode of production                                                                        |
| 27         | Fundamentals of weed management under organic mode of production                                                                                    |
| 28         | Operational structure of NPOP                                                                                                                       |
| 29 & 30    | Certification process and standards of organic farming                                                                                              |
| 31 & 32    | Processing, labelling, economic considerations and viability, marketing and export potential of organic products                                    |

**OBJECTIVE:**

- To educate the students on the relevance of farming systems and organic farming in present context and imparting training about biological intensive nutrient management, vermincomposting, greenmanuring and integrated farming systems etc.
- To throw a light on students regarding the organic certification.

**LEARNING OUTCOME:**

- The course name farming systems and organic farming for sustainable agriculture is important for students which will give an overview on how to develop enterprise that are sustainable and harmonious with the environment.
- It will give glance look to the students on how the sustainable agriculture is done by recycling the farm products without wasting in the farm.
- In this preparation of vermicompost, compost, different neem products for pest control were explained.
- A brief idea on different integrated farming system model were shown to students so that they can inter relate them in future as an entrepreneur. Through this organic farming, focus is given on how to create a pollution free environment and how to increase the soil fertility.
- A focus of light is thrown on the students which will be useful for them in RAWEP Programme while motivating the farmers from conventional farming to organic farming.

# LECTURE 1

## FARMING SYSTEM-SCOPE, IMPORTANCE, AND CONCEPT

### 1.1 Introduction

- Progress of a country depends on prosperity of farmers which depends upon adoption of improved technology and judicious allocation of resources
- To make farming economically viable and environmentally sound and sustainable.
- This can only be made possible through farming system approach as per the recommendations of several researchers
- Since, this can meet multiple objectives like
  - Poverty reduction
  - Food and nutritional security
  - Competitiveness
  - Sustainability

### 1.2 Definition

Farming- process of harnessing solar energy in the form of economic plant and animal product

System- set of inter-related, interacting and interdependent acting together for a common purpose and capable of reacting as a whole to external stimuli

Farming system - Farming system is defined as a population of individual farm system that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints for which similar developmental strategies and interventions would be appropriate (FAO- Farming system).

### 1.3 SCOPE OF FARMING SYSTEM

Farming system approach is an approach for developing farm-household system, built on principles of productivity, profitability, stability and sustainability.

- It emphasizes understanding of farm household, community inter-linkages, reviews constraints and assess potentials.
- It combines improvements designed for better technology.

➤ It is continuous dynamic and interactive learning process based on analysis, planning, testing, monitoring and evaluation.

#### **1.4 NEED OF FARMING SYSTEM**

- To develop farm-household system and rural communities on a sustainable basis.
- To improve efficiency in farm production.
- To raise farm and family income.
- To increase welfare of farm families and satisfy basic needs.

#### **1.5 AIMS OF FARMING SYSTEM**

- Minimise soil disturbance by minimising mechanical tillage to maintain soil organic matter, soil structure and overall soil health.
- Enhances and maintain a protective organic cover on soil surface
- Cultivate wider range of plant.

#### **1.6 IMPORTANCE OF FARMING SYSTEM**

- Reduces risk of monoculture
- Promotes enterprise diversification
- Promotes value addition
- Development of alternate income sources with efficient utilization of farm resources
- Provides opportunity for effective recycling of products and by-products
- It helps to generate flow of cash to farmers year round.

#### **1.7 CONCEPT OF FARMING SYSTEM**

- Income through arable land alone is insufficient for bulk of marginal farmers, other activities such as dairy, poultry, sericulture, apiculture, fisheries etc. assume critical importance in supplementing the farm income.
- To evolve technically feasible and economically viable farming system model by integrating cropping with allied enterprises for irrigated, rainfed, hilly and coastal areas with a view to generate employment and income from the farm.
- A judicious mix of any one or more of these enterprises with agronomic crops should complement the farm income and help in recycling the farm residues/wastes. Selection of enterprises must be

based on the cardinal principles of minimising the competition and maximising the complementary between the enterprises.

Summarized concept: It is a holistic approach, complex in nature, inter-related of components, matrix of soils, plants, animals, power, implements, labour, capital and other inputs, influenced by political, economic, institutional and social factors.

## LECTURE - 2

# TYPES AND SYSTEMS OF FARMING SYSTEM AND FACTORS AFFECTING TYPES OF FARMING

### 2.1 Types of farming system

#### 1. Based on nature and purpose of farming

- Subsistence farming: Entire production is for family consumption.
- Commercial farming: Entire surplus is to sell in the market.
- Intensive farming (Maximum output per unit of land): The farms are usually small wherein high inputs of money, labour or technology is used to achieve high output or yield from unit area of land.
- Extensive farming: It is practiced in large patches of land. Although production from such huge patches is more but production per unit land is low.
- Plantation farming: It is the farming in estates where single cash crop is grown for sale.
- Mixed farming: It refers to the livestock production along with usual cultivated crops.

#### 2. According to cultivation

- Collective farming: Direct collection of plant products from non-arable land.
- Cultivation farming: Farmers cultivates the land for growing crops and rearing livestock.

#### 3. According to size of farm

- Small scale farming: Farming done on small size of holding and other factors of production are small in quantity and scale of production is also small.
- Large scale farming: Farming done on large size holding with large amount of capital, large labour force, large organisation and large risk.

#### 4. According to value of produce

- Intensive cultivation: Land remains fixed while other factors are increased.
- Extensive cultivation: More area can be brought under cultivation to increase the output.

#### 5. According to value of the produce and income

- Specialized farming: Farm in which 50% or more income of total crop production is derived from a single crop
- Diversified farming: Farm in which no enterprise is contributing to 50% or more income
- Mixed farming: Combination of crop with rearing of livestock where at least 10% of its gross income must be from livestock activity.

6. Indigenous farming system:

- Shifting cultivation: It refers to farming system in North-Eastern areas in which land under vegetation is cleared by slash and burn method. Traditionally, fallow period is 10-20 years but in recent times it is reduced to 2-5 years
- Taungya cultivation :Scientifically managed shifting cultivation Originated from Myanmar Growing annual arable crops along with the forestry species during early years of establishment
- Zabo cultivation : Zabo means impounding of water. Usually it is practiced in Nagaland. Rain water is collected in ponds and cultivation fully depends on amount of water stored in pond. It is practiced in hill tops where terraces cannot be constructed.

**2.2 FACTORS AFFECTING TYPES OF FARMING**

1. Natural resources and climate
2. Science and technology
3. Trade liberalisation and market development
4. Policies, institutions and the public good
5. Information and human capital
6. Indigenous Technical Knowledge (ITK)

**1. Natural resources and climate:**

- Interaction of natural resources, climate and population determines the physical basis for farming system
- Increased variability of climate and thus agricultural productivity substantially increases the risks faced by farmer thus reducing investment and input use
- Especially in arid regions climate is a major determinant and all the perpetual climatic problems in these areas determine the farming system
- In smaller farming system women are largely responsible for selection, improvement and adaption of high yielding varieties. They are also responsible for management of small livestock

**2. Science and technology:**



- Appropriate technology for different agro-climatic conditions and local needs of the people determine the farming system in that region
- During last 4-5 years investment in agriculture science and technology expanded resulting in technical and institutional reforms
- Present day research is much focussed intensifying crop and livestock production

### **3. Trade liberalization and market development**

- Marketing and processing are basic two pre-requisites for promoting IFS under given agro-ecological conditions
- If market for alternative produce from IFS is assured then farmers are motivated to diversify farming
- Trade liberalization is not only accelerating market development, but also patterns of production and natural resource usage are also changing due to market forces
- Trade liberalization, availability of new production, post harvest and transport technologies will also change demand patterns by making possible the delivery of new products in new forms to market.

### **4. Policies, Institutions and the public good**

- Policy framework of government for rural infrastructure transport, irrigation, storage facilities, processing and providing incentives to the farmers encourages agricultural diversification.
- Dynamic farming system requires a conducive policy environment.
- Production incentives have a dramatic effect on farming system.
- Policies on land ownership, water management and taxation reforms have great bearing on types of farming system in a region.

### **5. Information and Human capital**

- Evolution of farming system based on increasing specialization or integrated intensification requires extra knowledge on the part of farm operators.
- This shows that there is a need of better information and enhanced human capital is increasing.
- Better access to credit, land and extension services would enable women to make an even greater contribution to eliminating rural hunger and poverty.

### **6. Indigenous Technical Knowledge**

- ITK is that which people in a given community have developed over time and continue to develop.
- It is based on experience, often tested over longer periods of use and thereby lays emphasis on minimising risks rather than maximizing profits.

## LECTURE 3 & 4

### FARMING SYSTEM COMPONENTS AND THEIR MAINTENANCE

#### 3.1 Plant interactions

##### 3.1.1 Interactions between component crops

In intensive cropping, crops are grown in association (intercropping) or in sequence (sequential cropping). In such situations there is possibility of interaction between the component crops. The interaction is mainly due to response of one species to the environment as modified by the presence of other species. Interaction may be competitive or non-competitive or complementary.

##### 3.1.2 Interactions in intercropping

Factors such as light, water, nutrients, oxygen and CO<sub>2</sub> are required for plant growth. In mixed or intercropping situations, the component species compete for the growth factors. The close proximity of the species causes sub-optimal utilization of the growth factors and hence there is inequitable distribution of resources among the plants. Generally competition will develop between two components or within the components.

- a) **Light:** Intercropping can increase light interception by as much as 30-40%. When one component is taller than the other in an intercropping system, the taller component intercepts most of the solar radiation. In intercropping situation where the component crops have different growth durations, the peak demand for light would occur at different times. In such combinations, competition for light is less among the component crops and there is greater light use in intercropping than in pure stands. In general the component crops under intercropping situations are grown in such a way that competition for light is minimized. Proper choice of crops and varieties, adjustment of planting density and pattern are the techniques to reduce competition and increase the light use efficiency.
- b) **Moisture and nutrients:** Competition for water and nutrients results in two main types of effects on the less successful or suppressed component. First, the roots of dominated crop may grow less on the sides of aggressive component. The suppressed components adapt to such conditions by increased capacity for uptake. Also, if one part of the root system is on the depleted side, the remaining part shows compensatory activity and vigour. Secondly, plants affected by competition for soil factors are likely to have increased root/shoot ratio.
- c) **Allelopathy:** Allelopathy is any direct or indirect harmful effect that one plant has on another through the release of chemical substances or toxins into the root environment. Some crops may be unsuitable in to be grown as intercrops because they may produce and excrete toxins into the soil which are harmful to other components.

**d) Annidation :** Annidation refers to complementary interaction which occurs both in space and time.

**Annidation in Space:** The canopies of component crops may occupy different vertical layers with taller component tolerant to strong light and high evaporative demand and shorter component favouring shade and high relative humidity. Thus, one component crop helps the other. Multistoreyed cropping in coconut gardens and planting of shade trees in coffee, tea and cocoa plantations use this principle. Similarly, root systems of component crops exploit nutrients from different layers thus utilizing the resources efficiently. Generally, one component with shallow root system and another with deep root system are selected for intercropping as in *Setaria* (shallow) + red gram (deep) intercropping system.

**Annidation in Time:** When two crops of widely varying duration are planted, their peak demands for light and nutrients are likely to occur at different periods, thus reducing competition. When the early maturing crop is harvested, conditions become favourable for the late maturing crop. This has been observed to occur in sorghum + red gram, groundnut + red gram and maize + green gram intercropping systems.

**Other Complementary Effects:** In an intercropping system, involving a legume and a non-legume, part of the nitrogen fixed in the root nodule of the legume may become available to the non-legume component. The presence of rhizosphere microflora and mycorrhiza on one species may lead to mobilization and greater availability of nutrients not only to the species concerned, but also to the associated species. Another example is the provision of physical support by one species to the other in intercropping system. Erect crop plants may improve the yield of a climber as in the case of coconut +pepper, maize + beans. The taller component acts as wind barrier protecting the short crop as in maize+ groundnut, onion + castor and turmeric + castor.

### **3.1.3 Interactions in Sequence Cropping**

Competition for light, water and nutrients as in mixed crop communities does not occur when sole crops are grown in sequence. It occurs only in relay cropping where there is a short span of overlapping between two crops in a sequence and the relay crop experiences the shortage of light. The important purpose in sequential cropping is to increase the use of solar radiation. It is achieved by longer field duration and rapid ground coverage. Crops are raised one after another to keep the land occupied by the crop for longer period. If the crop development is slow, much of the solar radiation reaches the ground, favouring weed growth and increasing evaporation losses from the soil surface.

In sequential cropping, the proceeding crop has considerable influence on the succeeding crop mainly by changes in soil conditions, presence of allelopathic chemicals, shift in weeds and carry

over effects of fertilizers, pests and diseases. Field preparation is difficult after rice crop since soil structure is destroyed due to puddling. Crops like sorghum and sunflower leave toxic chemicals in the soil which do not allow germination of subsequent crops. The previous leguminous crop leaves considerable amount of nitrogen for the succeeding crop. Phosphorous applied to the previous crop is available for the succeeding crop. Weed number and species differ in the succeeding crop due to the effect of the previous crop. Wheat crop that follows rice suffers from high density of *Phalaris minor*. The pests and diseases in crop stubbles and other residues of the previous crop may infect the subsequent crop.

### **3.2 CROPPING SYSTEM MANAGEMENT**

The principles involved in management of intercropping and sequence cropping system are different. Intercropping is practiced with two objectives: to get additional yield through an intercrop as a bonus and to avoid risk.

#### **3.2.1 Management of Intercropping Systems**

The crops in intercropping system are grown simultaneously. Management practices that are followed should, therefore, aim to provide favourable environment to all the components, exploit favourable interactions among the component crops and minimize competition among the components.

- a) Seedbed Preparation.** Seedbed preparation for different crops varies depending on the crop. Deep rooted crops respond to deep ploughing while for most of the cereals shallow tillage is sufficient. The crops with small seed require fine seedbed. Certain crops like cotton and maize are planted on ridges, while most of the other crops are grown on flat seedbed. Since more than one crop is involved in intercropping, the seedbed preparation is generally done as per the needs of base crop. The seedbed for sugarcane, as usual, is made into ridges and furrows. Sugarcane is planted in furrows and intercrops are sown on ridges. In groundnut + red gram intercropping system, flat seedbed is preferred for sowing the crops. However, ICRISAT is recommending broad bed and furrows for black soils of semi-arid regions for pure crops as well as intercrops grown under rainfed conditions. Where the crop requirements are quite different as in rice + maize under rainfed conditions and also in agro-forestry, seedbed preparation is done separately for component crops. In rice + maize intercropping system, ridges and trenches are formed. Maize is planted on ridges and rice in trenches. In agro-forestry, pits are dug for tree species and a rough seedbed is prepared in interspace for the introduction of forage crops.
- b) Varieties:** The varieties of component crops selected for intercropping system should be less competing with the base crop and the peak nutrient demand period should be different from the base crop. The difference in duration between the components in intercropping should be a minimum period of 30 days. The short duration sorghum hybrids like CSH-6, CSH-9 are suitable

for intercropping with long duration red gram varieties like C 11 and LRG 30 because of wider gap between maturity periods. Selection of compatible genotypes of component crops increases the complementarity of intercropping system. The varieties selected for intercrop should have thin leaves, tolerant to shading and less branching since these crops are generally shaded by the base crop. If the base crop is shorter than intercrop, the intercrop should be compact with erect branching, and its early growth should be slow. The characteristics of base crop should be as in sole crop.

c) **Sowing:** Sowing practices are slightly altered to accommodate intercrop in such a way that it causes less competition to the base crop. Sowing of base crop is done either as paired row, paired wider row or skip-row planting. The sowing of base crop and intercrop is also done in fixed ratios. In paired-row planting, two rows of base crop are brought close by reducing inter-row spacing. The spacing between the two pairs of rows is increased to accommodate the intercrop. For example, the normal row spacing of rainfed groundnut is 30 cm. The row spacing is reduced to 20 cm between the paired rows and 50cm spacing is given between two pairs of rows. The spacing in paired row planting designated as 20/50 cm indicates that the spacing between two rows in a pair is 20 cm and among the pairs 50 cm. Similarly, pearl millet is planted with row spacing of 30/60 cm in paired row planting. These changes in crop geometry do not alter base crop yield, but intercrops are benefited to some extent. The seed drill used for normal planting contains tynes with uniform spacing. The spacing of the tynes on the beam of seed drill is to be changed to 20/40 or 30/60 as per requirement for sowing in paired rows. Planting in fixed ratio of intercrops is most common. The intercropping system of groundnut + redgram is either in 5: 1 or 7: 1 ratio and sorghum + redgram in 2: 1 ratio. In these cases, the normal three tyned or four tyned seed drill can be used without any modification. The hole pertaining to intercrop row in the hopper is closed with a piece of cloth. In that row, intercrop is sown with *akkadior kera*.

In traditional cropping systems, the component crops are grown with sub-optimum population. Yields of intercrops can be increased with higher plant population. For higher yields, base crop population is maintained at its sole crop population and intercrop population is kept at 80% of its sole crop population. Even 100% population of both the crops is maintained with advantage in some intercropping systems. For example, sorghum red gram intercropping with 100% population of both crop (180 x 103 and 50 x 103) gives higher yield than lower population of these crops. When the difference in duration of component crops is less than 30 days, staggered planting is done to increase the difference in duration. The aggressive or dominant crop is sown 10 to 15 days after sowing the dominated crop.

d) **Fertilizer Application:** The amount of nutrients present in the component crops indicates the requirement of fertilizers for the intercropping system. The nutrient uptake is generally more in

intercropping system compared to pure crops. When legumes are associated with cereal crop in intercropping system, a portion of nitrogen requirement of cereal is supplemented by the legume. The amount may be as small as a few kilograms to 20 kg/ha. Application of higher dose of nitrogen to the cereal + legume intercropping system not only reduces the nitrogen fixation capacity of legume, but also growth of legume is suppressed by aggressive cereals owing to fast growth of cereals with increased availability of nitrogen. Cereal + legume intercropping, is therefore; mainly advantageous under low fertilizer application.

Considering all the factors, it is suggested that the nitrogen dose recommended for base crop as pure crop is sufficient for intercropping system with cereals + legume or legume + legume. With regard to phosphorus and potassium, one-eighth to one-fourth of the recommended dose of intercrop is also added in addition to recommended dose of base crop to meet the extra demand. Basal dose of nitrogen is applied to rows of both components in cereals + legume intercrop system. Top dressing of nitrogen is done only to cereal rows. Phosphorus and potassium are applied as basal dose to both crops.

- e) **Water Requirement:** Intercropping systems are generally recommended for rainfed crops to get stable yields. The total water used in intercropping system is almost the same as for sole crops, but yields are increased. Thus water-use efficiency of intercropping is higher than sole crops. The component crops differ on their capacity to withstand excess or difficult moisture conditions. However the irrigation schedule followed for sole crops is suitable even for intercropping system. Scheduling irrigation at IW/CPE ratio of 0.6 to 0.8 or irrigation at one bar soil moisture tension is suitable for most of the systems. However, information on this aspect is meager.
- f) **Weed Management:** Weed problem is less in intercropping system compared to their sole crops. The higher plant population and complete covering of the soil earlier in intercropping system reduce weed infestation. In late maturing crops that are planted on wide rows, presence of early maturing crops helps to cover the vacant inter row space and keep weeds under check. In certain situations, intercrops are used as biological agents to control weeds. Black gram, green gram, cowpea in sorghum and cowpea in banana reduce weed population and one hand weeding can be avoided by this method.

However, in some intercropping systems like maize + groundnut, rice + tapioca, maize + tapioca, weed problem is similar to their sole crops. The growth habit of genotype used in intercropping has a great influence on weed growth. Early crop canopy to cover the soil is more important than rapid increase in plant height. It is very well known that different species of weeds are associated with different crops. This is due to differences in weed management practices like tillage, herbicides etc., and also due to crop-weed interference. For these reasons, weeds present in sole crops are different than those present in intercropping systems. At

Hyderabad, mixed weed flora appeared in sole crop of pearl millet and dominant weeds such as *Celosia*, *Ditaria* and *Cyperus* in sole crop of groundnut. In pearl millet and groundnut intercropping system, the type of weeds change with the proportion of component crops. As more rows of groundnut are introduced in place of pearl millet rows, there is a striking increase in both numbers and biomass of the tall and competitive *Celosia*, especially in groundnut rows.

Though weed problem is less, weed control measures are necessary in intercropping system. But the labour required for weeding is less. Second weeding is not necessary because of crop coverage. Chemical weed control is difficult in intercropping system because the herbicide may be selective to one crop, but non-selective to another. Atrazine gives good weed control in sole crop of sorghum, but it is not suitable for sorghum + redgram intercropping system as it is toxic to red gram. However, some herbicides are identified to suit both components (Table 1).

**g) Pests and Diseases:** Pests and diseases are believed to be less in intercropping system due to crop diversity than in sole crops. Some plant combinations may enhance soil fungistasis and antibiosis through indirect effects on soil organic matter content. The spread of the disease is altered by the presence of different crops. Little leaf of brinjal is less when brinjal is sheltered by maize or sorghum.

As the insect carrying virus first attacks maize or sorghum, virus infection is less on brinjal. Non-host plants in mixtures may emit chemicals or odours that affect the pests, thereby protecting host plants. Trap crops are host crops sown to attract nematodes but destined to be harvested or destroyed before the nematodes manage to hatch. This is advocated for cyst nematodes. The technique involves sowing of crucifers and ploughing in before the nematodes of beets can develop fully. Similarly, in pineapple plantations, tomatoes are planted and ploughed in to reduce root-knot nematodes. There is also evidence that some plants adversely affect nematode population through toxic action. Marigold reduces the population of *Pratylenchus* nematode worms.

### 3.3 Management of Sequential Cropping Systems

Unlike intercropping, crops are grown one after another in sequential cropping and hence, management practices are different.

**a) Seedbed Preparation:** The suitable type of seedbed for a particular crop can be prepared in sequence cropping systems like puddling for rice, ridges and furrows for vegetables, maize and cotton and flat seedbed for several other crops. However, two problems are encountered in seedbed preparation in sequential cropping system.

1. The time available for seedbed preparation is less in high intensity cropping system. Rains very frequently interfere with land preparation.

2. Due to the effect of the previous crop, the field may not be in proper condition to carry out field operations. For example, field preparation after rice is difficult. It is mainly because soil structure is destroyed during puddling. The turn-around time, the time between harvesting of crop to sowing of next crop, is more if rice is the preceding crop. To avoid this problem, minimum tillage or zero tillage is adopted. It is a common practice to sow pulse crop just before or immediately after harvesting rice crop. In rice-wheat system, the rice stubbles are killed by spraying paraquat and wheat is sown in plough furrows between stubbles of rice. In Indonesia, Sorjan system has been developed to overcome this problem. In this system, upland and lowland crops are grown in alternate strips; rice is grown in the flooded strips, while maize, beans, mung bean, sorghum, cassava, cowpea or sweet potato are grown in the upland or elevated strips. During the dry season, cassava or sorghum is grown in the upland areas on residual moisture, while a catch crop of a legume or maize is grown where the rice has been harvested. A major constraint in the Sorjan system is the labour required to build and maintain permanent raised planting areas.

It is not possible to practice zero or minimum tillage in all sequence cropping systems. If sunflower is the preceding crop, ploughing is essential to oxidize the allelochemicals of sunflower. The stubbles of pearl millet and sorghum which contain high C: N ratio immobilize N. It is, therefore, necessary to remove them. They also interfere with running of sowing equipment. Generally tillage operations are done at the beginning of the season (for the first crop) and subsequently, zero tillage is practiced for other crops in the system. In rice-rice-green gram system, summer ploughing is done and later when water is available in the rainy season, puddling is done and first crop is sown. For the second crop, minimum tillage is done just to incorporate crop residues and rice is planted. Green gram is sown as a relay crop in the second rice crop. In cotton-sorghum-finger millet cropping system in garden lands, thorough field preparation is done and the field is laid out into check basins to transplant finger millet. In the next season, cotton is planted among the stubbles of finger millet without any land preparation. Weeds are controlled by inter-cultivation in cotton at subsequent stages. In Nigeria, 'no till' planting of sorghum into residues of the previous crop maintains the seed at 10°C lower temperature at 5 cm depth than conventional clean-tilled planting. In the latter tillage system, temperature in the seeding zone reaches 4 °C.

**b) Varieties:** Short duration varieties of crops are selected to fit well in multiple cropping system. Photo insensitive varieties are essential for successful sequence cropping system. Most of the high yielding varieties are photo insensitive and intensive cropping is possible with the introduction of these varieties.

**c) Sowing:** Unlike in intercropping system, sowing is not a problem, provided there is sufficient time for seedbed preparation. If the proper seedbed is not prepared, establishment of crops is difficult. Special seeding technique and equipment are necessary under these conditions. For example,



cotton establishment is difficult in heavy black soils after rice. Due to hard pans in the shallow layer, root penetration is hindered. Sufficient time is not available for field preparation. If the fields are allowed to dry sufficiently for field preparation, nearly a month time is lost. Hence seedlings are raised either on twisted paddy straw or leaf cups before harvesting of rice crop. After harvesting, a crow bar hole is made up to 30 cm. It is partly filled with sand and soil mixture and cotton seedlings are planted.

The establishment of a pulse crop after rice is also difficult. Broadcasting of seeds in standing rice crop or rice stubbles results in uneven germination and high seed rate is necessary. Crops planted in stubbles are subjected to competition from regenerated stubbles. It can be overcome by spraying paraquat or diquat on stubbles. Delay in sowing or planting is the most common problem in intensive cropping systems. Situation necessitates transplantation with over aged seedlings. To reduce yield loss due to transplantation of over aged seedlings, higher level of nitrogen is applied to induce tillering. In rice-wheat system, wheat yields are reduced considerably when the sowings of wheat are delayed beyond November. In such situations, transplantation of 40 to 50 days old seedlings of wheat is done. Farmyard manure is broadcasted over the field to maintain higher soil temperature during December.

**d) Fertilizer Application:** Determining the fertilizer schedule is complex in sequential cropping system as several factors have to be considered. The important factors are: soil supplying power, total uptake by crops, residual effect of fertilizers, nutrients added by legume crop, crop residues left on the soil and efficiency of crops in utilizing the soil and applied nutrients.

**1. Soil Supplying power:** Soil contribution to the crops should be known before deciding on the quantum of fertilizer application. The results of long term fertility trials revealed that there is no appreciable change in the soil physical properties and soil deficiency for micronutrients as a consequence of multiple cropping. However, zinc in light alluvial soils (sandy soils) of Ludhiana and iron in medium black soils of Coimbatore have been found to be critical. The soil nutrient status, estimated by soil analysis at the beginning of the season is altered by growing different crops during different seasons. The soil supplying power increases with legume in rotation, fertilizer application and addition of crop residues (Table 3). The available nitrogen and potassium in soil after groundnut crop are higher compared to initial status of the soil. But after pearl millet, only potassium status in the soil is improved and there is no change in phosphorus status.

**2. Nutrient Uptake by Crops:** The total amount of nutrients taken by the crops in one sequence gives an indication of the fertilizer requirement of the system. Balance sheet approach is followed to know whether the amount of fertilizers applied is equal, more or less to the total uptake of nutrients by different crops in the system. The balance is obtained by subtracting the fertilizer applied to crops in the system from the nutrients taken up by the crop.

**3. Residual Effect of fertilizer:** The extent of residues left over in the soil depends on the type of fertilizer used. Because of their mobility and solubility, nitrogenous fertilizers leave no residues after the crop is harvested. 15N studies have shown that only 1 to 2 % of nitrogen applied to maize was taken up the following wheat crop. However, residues of nitrogen occur only when previous crop yields are poor. Phosphatic fertilizers and farmyard manure leave considerable residue in the soil which is useful for subsequent crops. Farmyard manure applied to the previous crops: used only 50% of its nutrients and rest was available for subsequent crops. The residues left by potassium fertilizers are marginal.

**4. Legume Effect:** Legumes add nitrogen to the soil in the range of 15 to 120 kg N/ha. The amount of nitrogen added depends on the crop and also on the purpose for which it is grown. Green gram grown for grain contributes 15 to 20 kg N/ha to the succeeding crop. Cowpea grown for grain and fodder contributes 24 and 30 kg N/ha, respectively to the succeeding crop. Inclusion of leguminous green manures in the system adds 40 to 120 kg N/ha. The availability of phosphorus is also increased by incorporation of green manure crops. Potassium availability to subsequent crop is also increased by groundnut.

**5. Crop Residues.** Crop residues add considerable quantity of nutrients to the soil. Cotton planted in finger millet stubbles benefits by 20 to 30 kg N/ha due to decomposition of finger millet stubbles. Deep rooted crops like cotton and red gram absorb phosphorus and other nutrients from deeper layers. Leaf fall and its subsequent decomposition add phosphorus to the top layers. Crop residues containing high C: N ratio like stubble of sorghum and pearl millet temporarily immobilize nitrogen. Residues of leguminous crops contain low C: N ratio and, they decompose quickly and release nutrients.

**6. Efficiency of crops.** Crops differ in their ability to extract and forage nutrients from different layers of soils and their capacity to utilize them for the production of economic products. Jute is more efficient crop for utilization of nitrogen followed by summer rice, rainy-season rice, maize, potato and groundnut in that order. The order of phosphorus efficient crops are jute > summer rice> kharif rice>potato> groundnut > maize. Groundnut is more efficient in potassium utilization and the other crops their order of efficiency are maize, jute, summer rice, rainy-season rice and potato.

Fertilizer recommendation should be made to the cropping system considering all the above factors. For example, in wheat based cropping systems, an extra dose of 25 % nitrogen is recommended for wheat when it is grown after sorghum or pearl millet. Wheat after pulse crops like red gram, green gram or black gram needs 20 to 30 kg less nitrogen per hectare. When phosphatic fertilizers are added to green manure crop, there is no necessity to apply phosphorus to succeeding wheat crop. In rice wheat cropping system, recommended dose of nitrogen of crops has to be applied. However, it is sufficient to apply phosphorus to wheat and potassium to rice but not for both crops of the system. In

rice-rice-pulse cropping system, nitrogen has to be applied to both the rice crops, phosphorus to dry season rice and potassium, sulphur and zinc, if necessary to the second crop. In rice based cropping system consisting of rice-rice in kharif and rabi and sorghum, maize, finger millet, soybean in summer, it is sufficient to apply phosphorus and potassium to summer crops only while nitrogen is applied to all the crops. Thus, lot of fertilizer can be saved by following system approach in fertilizer recommendation.

**e. Water Management.** Water management for sequential cropping is same as for individual crops. There are no carry over effects of irrigation as in the case of fertilizer. Depending on the availability of water, suitable cropping system has to be selected. Rice-rice-rice is efficient cropping system for total yield, but it consumes large amount of water especially during summer. As availability of water in summer is less, instead of rice, groundnut is used in the cropping system. Rice-Rice-groundnut cropping system has high water use efficiency and high net returns. In wheat based cropping systems, depending on availability of water, cropping system is changed. When water is available for 10 irrigations, the efficient cropping system is maize-wheat, for 4 to 6 irrigations, black gram-wheat and for 2 irrigations fallow-wheat.

With regard to the-method of irrigation, the layout should be planned in such a way that it is suitable for most of the crops in the system. In rice- rice-groundnut system, rice is irrigated by flood method of irrigation, while for groundnut border strip method is suitable. In cotton-sorghum-finger millet system, cotton and sorghum is irrigated by furrow method, while for finger millet check-basin method is adopted. For this system, the field is laid out into check basins and finger millet is transplanted. After harvest of finger millet, cotton is planted in the check basins in finger millet stubbles. After a period of 30 days ridges and furrows are made for irrigating cotton. Furrows could be used for subsequent crop of sorghum.

**f. Weed Management.** Weed management practices are followed for the entire system as a unit instead of considering weed problem of individual crops. This is necessary because weed shift occurs due to crops grown in the system and the carry over effects of weed control methods on succeeding crop.

Weeds are dynamic in nature and occasional shifts in weed species occur due to change in environment brought about either by cultural practices or by weed control methods. Generally, broad leaved weeds occur in wheat at later stages and 2, 4-D is applied as post-emergence herbicide to control them. If weed shift occurs, this practice is not suitable. For example, in rice -wheat system canary grass (*Phalaris minor*) is a menace for wheat crop. The weed seeds of several species are decomposed and lose viability as soil is submerged for rice but *Phalaris minor* seeds do not lose viability. Wheat sown in rice stubbles is heavily infested with *Phalaris minor*. Weed seeds germinate even before the germination of crop seeds and there is severe competition from these weeds.

Similarly, in cotton - sorghum- finger millet sequence cropping with zero tillage, weeds are controlled by herbicides in two rotations. Weed flora shifts from annual weeds to perennial weeds and *Cynodactylonis* a problematic and dominant weed in this system.

Herbicides applied to the previous crop may be toxic to the succeeding crop. Higher dose of atrazine applied to sorghum crop affects germination of succeeding pulse crop. Recommendation of herbicides and its dose should, therefore, take into consideration the succeeding crop. When herbicides are applied at recommended doses, their residual effects on controlling weeds of the succeeding crop has not been observed. Ploughing the field well ahead of the planting season, either at the end of the rainy season or after summer rains, helps to kill most of the weeds and reduces weed problem. For subsequent crops, thorough field preparation may not be possible. Judicious use of physical, mechanical and chemical weed control methods have to be adopted.

**g. Pests and Diseases:** The infestation of pests and diseases are more in sequence cropping system due to continuous cropping. Carry over effects of insecticides are not observed so far.

**h. Harvesting:** In sequence cropping, the crop can be harvested at physiological maturity instead of at harvest maturity. The field can then be vacated one week earlier for planting another crop. Because of continuous cropping, the harvesting time may coincide with heavy rains and special postharvest operations like artificial drying, treating the crop with common salt etc. are practiced to save the produce.

## LECTURE 5

# CROPPING SYSTEMS AND PATTERNS, MULTIPLE CROPPING SYSTEM AND EFFICIENT CROPPING SYSTEMS AND THEIR EVALUATION

### 5.1 Cropping systems:

Cropping systems based on climate, soil and water availability have to be evolved for realizing the potential production levels through efficient use of available resources. The cropping system should provide enough food for the family, fodder to the cattle and generate sufficient cash income for domestic and cultivation expenses. The cropping systems, by and large, are affected by the national food need and the strategies planned to boost agricultural productivity. Cropping systems are the resultant product of principle and practices of cropping, resources, environment and available package of technology (production & management).

### 5.2 Cropping pattern:

The yearly sequence and spatial arrangement of crop or of crops and fallow on a given area (a farm), region, province or country apportioning due consideration to natural features (soil and climate), crop Efficiency, and capability, socio-economic structure, technological and extension infra-structure (changeable) and the national agricultural policy.

### 5.3 Multiple cropping

Multiple cropping refers to intensification of cropping both in time and space. It includes sequential cropping, inter-cropping and mixed cropping.

**a) Sequential cropping:** Growing two or more crops in a sequence on the same field in a farming year (twelve months) for irrigated land and is limited to the period of adequate soil moisture availability for crop growth in semi-arid & arid areas. The succeeding crop is planted after the preceding crop has been harvested. Crop intensification is only in time dimension. There is no inter-crop competition. Farmers manage only one crop at a time in the same field.

**b) Intercropping:** It refers to growing of two or more dissimilar crops simultaneously on the same piece of land, base crop necessarily in distinct row arrangement. The recommended optimum plant

population of the base crop is suitably combined with appropriate additional plant density of the associated/component crop. The objective is intensification of cropping both in time and space dimensions and to raise productivity per unit area and inputs by increasing the pressure of plant population. The following four types of inter-cropping are identified.

**i) Mixed inter-cropping:** Growing component crops simultaneously with no distinct row arrangement. This is commonly used in labour intensive subsistence Farming situations.

**ii) Row inter-cropping:** Growing component crops simultaneously in different row arrangement. This issued in mechanized agriculture.

**iii) Strip inter-cropping:** Growing component crops indifferent strips wide enough to permit independent cultivation but narrow enough to the crop to interact agronomically.

**iv) Relay inter-cropping:** Growing component crops in relay, so that growth cycles overlap. It necessarily does not mean planting of succeeding crop before flowering stage of preceding crop or attainment of reproductive stage of preceding crop. It refers to planting of succeeding crop before the harvest of preceding crop, planting of succeeding crop may be done before or after flowering before or after attainment of reproductive stage, completion of active life cycle, senescence of leaves or attainment of physiological maturity.

**5.4 Mixed cropping:** Mixed cropping is growing of two or more crops simultaneously on the same piece of land seeded either after the seeds of the crops intended to be grown mixed or sowing alternate rows in various replacement ratios. This may or may not have distinct row arrangement and the mixed plant community faces inter and intra row competition with a different plant type/variety. The basic objective in mixed cropping is minimization of risk and insurance against crop failure due to aberrant weather conditions. In inter-cropping systems, pressure of plant density per unit are is more than that in a sole cropping system, while in mixed cropping the plant population pressure is generally equal to sole cropping and in some cases it may even be less than sole cropping system.

Besides the above few other terms commonly used in cropping systems approach are defined below:

a. **Monoculture:** The repetitive growing of the sole crop on the same piece of land. It may either be due to climatologically limitation or due to specialization by a farmer to grow a particular crop.

- b. **Staggered planting:** It means sowing of a crop is spread over and around optimum period of planting either to minimize risks or to use labour & machinery more effectively or to minimize competition (in inter-cropping) or to prolong the period of supply to the market or the factories.
- c. **Ratoon cropping:** The cultivation of crops are growth coming out of roots or stalks of the preceding crop after harvest, although not necessarily for grain is termed as ratooncropping/ratooning.
- d. **Mixed farming:** It is defined as a system of farming on a particular farm (regardless of size) which includes crop production, raising of livestock, poultry, fish and bee keeping, and/or trees to sustain and satisfy as many necessities of the owner (farmer) as is possible. Subsistence is the objective here. It is based on the principle of give and take. Farm animals feed on farm produce and in return manure is given to the crop.

## 5.5 Importance of farming system

1. **Recycling and utilization of other available resources in the farm:** There is effective recycling of waste material in farming system. The word system itself signifies the assemblage of objects united by some form of regular interaction or interdependence. It is an organized unitary whole composed of two or more interdependent and interacting parts or components or sub-systems delineated by identifiable boundary or its environmental super system. Farming is a stochastic dynamic biological and open system with human and social involvement. It specifically refers to crop-combination or enterprise -mix in which the products and/or the by-products of one enterprise serve as the input for the production of other enterprise. Farming system includes agricultural crops, fruit trees, forest trees, forages, grasses and animals, which have potential to contribute to improve resource use and management.
2. **Maximum possible return and Profitability:** Use of waste material of one component in the other at the least cost reduces cost of production and net profit is increased. Due to interaction of enterprises like crops, eggs, milk, mushroom, honey, cocoons silkworm farming there is flow of money to the farmer round the year.
3. **Create adequate employment opportunities:** Combining crop with livestock enterprises would increase the labour requirement and help in reducing the problems of under employment. IFS provide enough scope to employ family labour round the year

4. **Productivity:** IFS provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.
5. **Potentiality or Sustainability:** Organic supplementation through effective utilization of byproducts of linked component provides an opportunity to sustain the potentiality of production base for much longer periods.
6. **Balanced Food:** The linked components of varied nature enable to produce different sources of nutrition.
7. **Environmental Safety:** In IFS waste materials are effectively recycled by linking appropriate components, thus minimize environment pollution.
8. **Adoption of New Technology:** Resourceful farmers (big farmer) fully utilize the technology due to linkage of different components (crop with dairy / mushroom / sericulture / vegetable). Money flow round the year gives an inducement to the small/marginal farmers to go for the adoption of latest technologies.
9. **Saving Energy:** Organic wastes available in the system can be utilized to generate biogas. This alternative source thus reduces our dependence on fossil energy sources within short time.
10. **Meeting Fodder crisis:** Every piece of farm area is effectively utilized. Plantation of perennial legume fodder trees on field borders fixes the atmospheric nitrogen. These practices will greatly relieve the problem of non – availability of quality fodder to the animal component linked.
11. **Solving Fuel and Timber Crisis:** By linking agro- forestry appropriately, the production level of fuel and industrial wood can be enhanced without any effect on crop. This will also greatly reduce deforestation, thus preserving our natural ecosystem.
12. **Agro – industries:** When one of produces in farming system is increased to commercial level, the surplus lead to the development of allied agro – industries.
13. **Increasing Input Efficiency:** Farming system provides good scope to use inputs in different component with greater efficiency and benefit cost ratio.



## LECTURE – 6, 7 & 8

### ALLIED ENTERPRISES AND THEIR IMPORTANCE

Components of farming system-In the integrated farming system, it is always emphasized to combine cropping with other enterprises/ activities, many enterprises are available and these includes cattle maintenance sheep or goat rearing, poultry, piggery, rabbit rearing, bee keeping etc. Any one or more can be combined with the cropping.

#### 6.1 Crop Production

Crop production is an integral part of farm activities in the country. Cropping systems based on climate, soil and water availability have to be evolved for realizing the potential production levels through efficient use of available resources. The cropping system should provide enough food for the family, fodder to the cattle and generate sufficient cash for domestic and cultivation expenses. These objectives could be achieved by adopting intensive cropping (multiple cropping and intercropping). Intensive cropping may pose some practical difficulties such as shorter turn-around time lapse for land preparation before the succeeding crop and labour shortage at peak periods of agricultural activities. These practical handicaps can easily be overcome by making modifications in the cropping techniques. Alteration of crop geometry may help to accommodate intercrops without losing the base crop population.

#### (I) Sequential Cropping Systems:

In sequential cropping, the preceding crop has considerable influence on the succeeding crop. This includes the complementary effects such as release of N from the residues of the previous crop, particularly legume, to the following crops and carries over effects of fertilizer applied to preceding crops. The adverse effects include allelopathy, temporary immobilization of N due to wide C/N ratio of the residues and carry over effect of pest and diseases.

In India, food crop is predominantly grown in most suitable seasons and thus particular food crop is basic to the cropping system followed by the farmers. Accordingly the cropping systems are usually referred to as:

- (i) Rice-based cropping system
- (ii) Sorghum-based cropping system
- (iii) Pearl millet-based cropping system
- (iv) Wheat and gram-based cropping system

Some of the cropping systems based on commercial crops are (i) cotton-based, (ii) groundnut-based, (iii) sugarcane-based, (iv) plantation crop-based and (v) vegetable-based cropping system. The grain production potential in different regions of the country under intensive cropping ranges from 11-18 t/ha. In maize-potato or toria-wheat-moong system followed at IARI, New Delhi, it

was possible to produce 14-15 tonnes of food per ha per annum without impairing the soil health. The results of multiple cropping demonstrations under irrigated conditions showed that production potential can be as high as 19.8 t/ha in cereal-based cropping system of rice-rice-rice. The yield potential of multiple cropping varies from region to region depending upon the physical and socio-economic conditions.

## **(II) Multi-tier Cropping:**

The practice of growing different crops of varying height, rooting pattern and duration is called 'multi-tier cropping' or multi-storied cropping. Multi-storied cropping is mostly prevalent in plantation crops like coconut and areca nut. There is scope for intercropping in coconut garden up to the age of 8 years and after 25 years. During this period there is adequate light transmission to the ground, which permits cultivation of intercrops. The objective of this system of cropping is to utilize the vertical space more effectively. In this system, the leaf canopies of intercrop components occupy different vertical layers. The tallest components have foliage tolerant of strong light and high evaporative demand and the shorter component(s) with foliage requiring shade and on relatively high humidity e.g. coconut + black pepper + cocoa + pineapple.

In this system, coconut is planted with a spacing of 7.5 m. Rooted cuttings of black pepper are planted on either side of coconut about 75 cm away from the base. On the coconut trunk at a height of about one meter from the ground level, the vines of pepper are trailed. A single row of cacao is planted at the center of space between coconut rows. Pineapple is planted in the inter-space.

Coconut growing to a height of more than 10 m occupies the top floor. Black pepper growing to about 6-8 m height forms the second floor. Cacao with its pruned canopy of about 2.5 m height and pine apple growing to about 1 m height form the first and ground floors, respectively.

In another multi-tier system in coconut, ginger or turmeric and partial shade loving vegetables form the first tier, banana in second, pepper in third and coconut or areca nut in the final tier. In the areca nut plantation, tuber crops are predominantly intercropped. Elephant yam, tapioca, greater yam and sweet potato are common intercrops in humid tropics. Banana and pine apple are also cultivated as intercrops in areca nut gardens. In coffee based multi-tier cropping system, first tier is with pine apple, second tier with coffee, third tier with cacao/mandarin and final tier with fast growing shade trees necessary for coffee plantation (e.g., dadaps and silver oak).

## **6.2. Dairy Farming**

Dairy farming is an important source of income to farmers. Besides producing milk and/or draft power, the dairy animals are also good source of farm yard manure, which is good source of

organic matter for improving soil fertility. The farm byproducts in turn are gainfully utilized for feeding the animals. Though the total milk production in the country as per current estimates have crossed 90 million tonnes/annum, the per capita availability is still about 220 g/day against the minimum requirement of 250 g/day as recommended by Indian Council of Medical Research.

The dairy sector in India is characterized by very large number of cattle and buffaloes population with very low productivity. Around 70% of Indian cows and 60% of buffaloes have very low productivity. This sector is highly livelihood intensive and provides supplementary incomes to over 70% of all rural and quite a few urban households. The sector is highly gender sensitive and over 90% of the households dairy enterprise is managed by family's women folk.

- (a) **Cattle Rearing:** Cattle rearing in India is carried out under a variety of adverse climatic and environmental conditions. The cattle are broadly classified into three groups.
  - (i) **Draft breeds:** The bullocks of these breeds are good draft animals, but the cows are poor milkers, e.g. Nagore, Hallikar, Kangeyam, Mali.
  - (ii) **Dairy breeds:** The cows are high milk yielders, but the bullocks are of poor draft quality, e.g., Sahiwal, Sindhi, Gir.
  - (iii) **Dual purpose:** The cows are fairly good milkers and the bullocks are with good draft work capacity, e.g., Haryana, Ongole and Kankrej.

Exotic breeds: The exotic breeds are high milk yielder e.g., Jersey, Holstein-Friesian, Aryshire, Brown Swiss and Guernsey.

- (b) **Buffaloes:** Important dairy breeds of buffalo are Murrah, Nili Ravi (which has its home tract in Pakistan), Mehsana, Suti, Zafarabadi, Godavari and Bhadawari. Of these Godavari has been evolved through crossing local buffaloes in coastal regions of Andhra Pradesh with Murrah.
  - (i) **Housing:** Each cow requires 12 to 18 m<sup>2</sup> space and the buffaloes need 12 to 15 m<sup>2</sup>. It is important to provide good ventilation and an open shed of housing is always preferable. Dairy building should be located at an elevated place to facilitate easy drainage. The floor should be rough and have gradient of 2.5 cm for every 25 cm length.
  - (ii) **Breeding and Maintenance:** The cows remain in milk for 9-10 months, the average calving interval being 16-18 months. A cow does not require more than 6-8 weeks of dry period. From the economic point of view, cow should ordinarily be bred during the second and third months after calving. In weak animals and heavy milkers, breeding may be delayed by 1 or 2 months. Cattle come to heat in more or less regular cycles of about 21 days which

lasts for about a day. The best time to serve a cow is during the last stage of heat. If artificially inseminated, it is better to inseminate for 3 days continuously to have better probability to conceive. The gestation period varies with individual cows and breeds and normally it is about 280 days.

In the case of buffaloes, the lactation period last for 7-9 months. She buffalo comes to heat every 21-23 days. The gestation period is 310 days. Calf rearing is very important in the case of buffalo maintenance. Since they require abundant water, wallowing is required. Regular de-worming is needed for buffalo maintenance.

Under Indian conditions, cattle commonly mature at the age of about three years. This period can, however, be reduced by six months under well-managed herd.

(iii) **Feeding:** Cattle feed generally contains fibrous, coarse, low nutrient straw material called roughage and concentrates as well as green fodder round the calendar year to harvest potential yield.

(iV) **Roughages:** Dairy cattle are efficient user of the roughages and convert large quantities of relatively inexpensive roughage into milk. Roughages are basic for cattle ratio and include legumes, non-legume hays, straw and silage of legume and grasses.

(V) **Concentrates:** Grains and byproducts of grains and oilseeds constitute the concentrates. They are extensively used in dairy cattle ration. These include cereals (maize, sorghum, oats, barley), cotton seeds, industrial wastes (bran or wheat, rice, gram husk) and cakes of oilseeds (groundnut, sesame, rapeseed, soybean, linseed).

(Vi) **Vitamins and mineral mixtures:** It is advisable to feed a supplement containing vitamins A and D. Mineral mixtures containing salt, Ca, Mg and P should also be provided in the ration.

The ration per animal per day includes concentrate @ 1 kg for 2 litres of milk yield, green fodder (20-30 kg), straw (5-7 kg) and water (32 litres).

### **6.3. Goat and Sheep Rearing**

The system of sheep and goat rearing in India is different from that adopted in the developed countries. In general, smaller units are mostly maintained as against large scale in fenced areas in the developed countries.

**6.3.1 Goat Rearing:** In India, activity of goat rearing is sustained in different kinds of environments, including dry, hot, wet and cold, high mountains or low lying plains. The activity is also associated with different systems such as crop or animal-based, pastoral or sedentary, single animal or mixed herd, small or large scale. Goat is mainly

reared for meat, milk, hide and skin. Goat meat is the preferred meat in the country. A goat on hoof (live goat) fetches a better price than a sheep on hoof.

(i) **Housing:** Goats can be maintained under stall-fed conditions. Successful goat rearing depends on the selection of site. Goats do not thrive on marshy or swampy ground. Goats are to be provided with a dry, comfortable, safe and secure place, free from worms and affording protection from excessive heat and inclement weather. The Kitts are kept under large inverted baskets until they are old enough to run along with their mothers. Males and females are generally kept together. The space requirement for a goat is 4.5 to 5.4 m<sup>2</sup>.

(ii) **Breeding and Maintenance:** Goat matures in about 6-7 months. Breeding is allowed for buck at one year and doe after 10 months of age. Gestation period is 145-155 days. It gives birth to 1-3 kitts per time. Number of evings is three per 2 years. The kitts can be weaned after 30-45 days. Mother can be allowed for mating 45-60 days after evings. Once in five years, the buck can be changed to avoid deterioration due to inbreeding. When the young ones attain a body weight of about 25-30 kg in about nine months, they can be sold.

(iii) **Feeding:** The requirement of nutrients per head in respect of goats is relatively low. Hence, they are suitable for resource poor small farmers with marginal grazing lands. They are essentially browsers and eat plants, which any other animals won't touch. Goats eat 4-5 times that of their body weight. Since the profit depends on weight addition, adequate proteins and calorie should be given to goats. They eat more of tree fodder and hence 40-50% of green fodder should contain tree leaf fodder and the rest with other grass species. Goats should be fed with concentrates of maize, wheat, horsegram, groundnut cake, fish meal and wheat bran. Common salt and vitamin. Abundant clean fresh water should be made available to goats. Water should be changed every morning and evening. Fresh water is required for digestion, blood circulation and removal of waste from the body. Water is also required for regulation of the body temperature.

**6.3.2 Sheep Rearing:** Sheep are well adapted to many areas. They are excellent gleaners and make use of much of the waste feed. They consume large quantities of roughage, converting a relatively cheap food into a good cash product. Housing need not be elaborate or expensive. However, to protect the flock from predatory animals, the height of the fencing should be raised to two meters.

Breeds of Indian Sheep: There are three types of sheep in India based on the geographical division of the country.

(i) **The Temperate Himalayan Region:** Gurez, Karanah, Bhakarwal, Gaddi, Rampur-Bushair.

(ii) **Dry Western Region:** Lohi, Bikaneri, Marwari, Kutchi, Kathiawari

(iii) **Southern Region:** Deccani, Nellore, Bellary, Mandya, Bandu

(i) **Breeding and Maintenance:** One ram can be maintained for 40-50 ewes. Rams are liable to fight when two or more of them are put in a pen. Unlike other farm animals, ewes in general do not come in heat at regular intervals throughout the year but are seasonal in this respect. The duration of the heat period will range from 1-3 days and 75% of the ewes remain in heat for 21-39 hours. The optimum time of service is towards the end of heat period. Average heat interval is 18 days during the breeding season. The gestation period will vary from 142-152 days with an average of 147 days. A normal ram is in full vigour for breeding from the age of 2½-5 years. Sheep grow fully at two years of age when the ewe is ready for breeding. Under average range conditions, ewes may be expected to produce about five crops of lambs.

(ii) **Feeding:** A sheep requires about 1-2 kg of leguminous hay per day depending on the age of sheep and its body weight. Proteins may be supplied through concentrates such as groundnut cake, sesame cake or safflower cake when the pastures are poor in legumes or when scarcity conditions prevail. Normally 110-225 g of cake is sufficient to maintain. Feeding a mixture of common salt, ground limestone and sterilized bone meal in equal parts is required to alleviate deficiency of minerals in the feed.

#### 6.4 Piggery

Pigs are maintained for the production of pork. They are fed with inedible feeds, forages, certain grain byproducts obtained from mills, meat byproducts damaged feeds and garbage. Most of these feeds are either not edible or not very palatable to human beings. The pig grows fast and is a prolific breeder, farrowing 10 to 12 piglets at a time. It is capable of producing two litters per year under good management conditions. The carcass return is high at 65-70% of the live weight.

(i) **Breeds:** Imported breeds of Large White Yorkshire and Landrace are being used widely. Yorkshire is the most extensively used exotic breed in India. It is a prolific breed having good carcass quality, growth rate and feed conversion ability. For a small breeding farm or unit, the selection of a herd boar is extremely important. A good boar weighs 90 kg in about 5-6 months and is strong on feet and legs. The mother of the pig to be selected should have large litters of eight piglets or more.

(ii) **Housing:** Housing should provide maximum comfort to pigs so that their growth is optimum. There should not be dampness, draft and over heating. Locally available materials can be used for housing. One pig requires about 2.7 sq.m. with a wall of 1.2 m height. Eight boars can be kept in 2.7-4.5 m<sup>2</sup> area with 2.4-6.0 m<sup>2</sup> open space.

**(iii) Feeding:** Feed plays an important role in successful pig production. Pigs are the most rapidly growing livestock and suffer more from nutritional deficiencies than the ruminants. Protein, carbohydrates, fats, minerals, vitamins and ample good water form a complete diet for pig. Pigs have a simple stomach; therefore, they must be fed with maximum of concentrates and minimum of roughage. The main ingredients of swine ration are cereals and millets and their byproducts. The fibre content in swine ration should be very low (around 5-6%) for better feed utilization efficiency. Mixed ration should also contain 0.5% of added salt. Swine requires comparatively higher percentage of Ca and P than do cattle or sheep. When pigs are maintained with agricultural/kitchen waste or fish and slaughterhouse waste, the cost of production remains low. On an average, the consumption of feed is 3.5% of total weight. Feed allowance is calculated as 2.5-3.0 kg/100 kg body weight + 0.25 kg feed per piglet with the lactating mothers.

**(iv) Management:** As a general rule, well-developed gilts weighing about 100 kg, when 12-14 months old, may be used for breeding. The body weight is more important than age at breeding. Sows with low body weight show higher rate of fetal and pre-weaning mortality and have been proved as mothers with poor nursing ability. The gestation period is on an average 114 days. Litter size at birth may be 1-16 numbers with the body weight of 1-25 kg. Normal period between birth of piglets is 10-20 minutes. Time taken for the whole process of farrowing ranges from 1.5 to 4.0 hours. Sows are weaned after 40 days. It is advantageous to cull the sow after fifth or sixth litter in a commercial herd. Weaned sows come into heat in 3-10 days after weaning and may be allowed to breed. The boar-sow ratio should be 1:15. It is profitable to raise two litters from each sow each year. Mortality in piglets is an important cause of heavy economic loss leading to failure of pig industry. In general, one fourth of piglets farrowed die before they are weaned. Another one tenth is also categorized into stunt or unprofitable group due to disease or parasite infection. Thus about 60-65% of the piglets farrowed perform as healthy piglets at slaughter age. Death rate is high during farrowing and the first week after farrowing. The farrowing season also determines mortality rate. Mortality in newborn piglets is maximum when farrowing takes place in acute cold or hot climate. Therefore, mating should be planned in such a way that farrowing could be avoided in such seasons.

## 6.5 Poultry

Poultry is one of the fastest growing food industries in the world. Poultry meat accounts for about 27% of the total meat consumed worldwide and its consumption is growing at an average of 5% annually. Poultry industry in India is relatively a new agricultural industry. Till 1950, it was



considered a back yard profession in India. In the sixties, the growth rate of egg production was about 10% and it increased to 25% in the seventies. The growth rate came down to 7-8% by 1990 due to price-rise in poultry feed. By 2000, the total egg production may reach up to 5000 crores. Broiler production is increasing at the rate of 15% per year. It was 31 million in 1981 and increased up to 300 million in 1995 (Singh, 1997). Nearly 330 thousand tonnes of broiler meat are currently produced. The average global consumption is 120 eggs per person per year and in India, it is only 32-33 eggs per capita year. As per the nutritional recommendation, the per capita consumption is estimated at 180 eggs/year and 9 kg meat/year.

- (i) **Breeds:** Specific poultry stocks for egg and broiler production are available. A majority of the stocks used for egg production are crosses involving the strains or inbred lines of white Leghorn. To a limited extent, other breeds like Rhode Island Red, California Grey and Australop are used. Heavy breeds such as white Plymouth Rock, White Cornish and New Hampshire are used for crossbred broiler chickens. Hence, it is essential to consider the strain within the breed at the time of purchase. Several commercial poultry breeders are selling day old chicks in India. It is best to start with the day old chicks.
- (ii) **Housing:** Adequate space should be provided for the birds. Floor area of about 0.2 m<sup>2</sup> per adult bird is adequate for light breeds such as white Leghorn. About 0.3-0.4 m<sup>2</sup> per bird is required for heavy breeds. The house should have good ventilation and reasonably cool in summer and warm during winter. It should be located on well-drained ground, safe from flood waters.
- (iii) **Feed:** The feed conversion efficiency of the bird is far superior to other animals. About 60-70% of the total expenditure on poultry farming is spent on the poultry feed. Hence, use of cheap and efficient ration will give maximum profit. Ration should be balanced containing carbohydrates, fats, minerals and vitamins. Some of the common feed stuffs used for making poultry ration in India are:

*Cereals:* Maize, barley, oats, wheat, pearl millet, sorghum, rice-broken.

*Cakes/meal:* Oil cakes, maize-gluten-meal, fish meal, meat meal, blood meal.

*Minerals/salt:* Limestone, Oyster shell, salt, manganese

From the day old to 4 weeks of age, birds are fed on starter ration and thereafter finisher ration, which contains more energy and 18-20% protein. Feed may be given 2-3 times in a day. In addition to the foodstuffs, antibiotics and drugs may also be added to the poultry ration. Laying hens are provided with oyster shell or ground limestone. Riboflavin is particularly needed.

- (iv) **Maintenance:** The chicks must be vaccinated against Ranikhet diseases with F<sub>1</sub> Strain vaccine within the first 6-7 days of age. One drop of vaccine may be administered in the eye

and nostril. When chicks get the optimum body weight of 1.0-1.5 kg around six weeks, they can be marketed for broiler. Hens may be retained upto the age of about 1½ years for egg production. One hen is capable of laying 180-230 eggs in a year starting from the six month. In addition, a laying hen produces about 230 g of fresh droppings (75% moisture) daily.

## 6. 6. Duck Rearing

Ducks account for about 7% of the poultry population in India. They are popular in states like West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Tripura and Jammu and Kashmir. Ducks are predominantly of indigenous type and reared for egg production on natural foraging. They have a production potential of about 130-140 eggs/bird/year. Ducks are quite hardy, more easily brooded and resistant to common avian diseases. In places like marshy riverside, wetland and barren moors where chicken or any other type of stock do not flourish, duck rearing can be better alternative.

- (i) **Breeds:** The important Indian breeds are Sylhet Mete and Nageswari, which are mostly found in the Eastern region of the country. Their annual production of 150 eggs/bird/year. Improved breeds for egg and meat production are available. Khaki Campbell and Indian Runner are the most popular breeds for egg laying. Khaki Campbell has a production of 300 eggs/bird/year. Indian Runner is the second best producer. White Pekin, Muscovy and Aylesbury are known for meat production. White Pekin is the most popular duck in the world. It is fast growing and has low feed consumption with fine quality of meat. It attains about 3 kg of body weight in 40 days. Indigenous types, however, still continue to dominate in duck farming. Desi ducks are robust, well adapted to local conditions and free of diseases.
- (ii) **Housing:** Ducks prefer to stay outside day and night even during winter or rains. In mild climate, it is possible to raise ducks without artificial shelter. A light fence of at least 1.2 m high enclosing the yard is enough to stop any predators. One nest of size 0.3 x 0.3 x 0.45 m to every 3 ducks is sufficient. In case of laying birds, a mating ratio of 1 drake: 6-7 ducks and in meat type 1:4-5 is allowed. The duck house should be well ventilated, dry, leaf and rat proof. The roof may be of thatched or asbestos sheeted. A water channel of 0.5 m wide and 0.20 m deep is constructed at the far end on both sides parallel to the night shelter in the rearing or layer house.
- (iii) **Feeding:** Ducks normally require lesser attention. They supplement their feed by foraging, eating fallen grains in harvested paddy fields, small fishes and other aquatic materials in lakes and ponds. However, for intensive rearing, pellet feeding may be given. Ducks prefer wet mash due to difficulties in swallowing the dry mash. Hence, ducks should never have access

to feed without water. During the first 8 weeks, birds should always have an access to feed. Later on they must be fed twice a day in the morning and late afternoon.

- (iv) **Maintenance:** The general management of ducks is similar to that of the chickens. The incubation period is 28 days. A broody duck or hen may be used for small scale hatching and incubator for large scale hatching. During the early part of the life, newly hatched ducklings require warm temperature under the natural or village conditions. A duck or broody hen can take care of 10-15 ducklings. Artificial brooding may be resorted for large number of ducklings. High egg-laying strains of duck come into production at 16-18 weeks of age. Ducks are resistant to common avian diseases. Some of the common diseases in duck are duck plague, duck virus hepatitis, duck cholera and aflatoxicosis.

## 6.7 . Apiculture

Apiculture is the science and culture of honeybees and their management. Apiculture is a subsidiary occupation and it is a additional source of income for farm families. It requires low investments and so can be taken up by small, marginal and landless farmers and educated unemployed youth.

**(i)Species:** There are two bee species, which are most commonly grown in India. They are *Apis cerana indica* and *A. mellifera*, are complementary to each other but have different adaptations. *A. cerana* is known as Indian bees, while *A mellifera* is known as European/western bee.

***Apis cerana:*** serves commercial bee keeping in most parts of the country and is reared mostly in ISI-A Type bee-hive. *Apis cerana* has instinctive behaviour of swarming and absconding. Its honey yield varies from 12 to 15 kg/ hive/ annum with foraging range between 0.8 and 1.0 km.

***Apis mellifera:*** This species has achieved a great success in northwestern states of India. Its worker cell is 5.3 mm in width and drone cell is 1-3 times larger. Average honey production from this species is between 30 and 40 kg/ hive/annum with foraging range extending up to 2-3 km.

**(ii) Management:** The beekeeper should be familiar with the source of nectar and pollen within his locality. Bee flora species are specific to different areas and have micro regional habitats. Under subtropical climates of India, nectar and pollen sources are available for most part of the year, but continuous succession throughout the year is lacking in some localities. Flowers of large number of plants species are visited by honeybees for nectar and pollen. The most important sources of nectar and pollen are maize, mustard, sunflower and palm, litchi, pongamia, coconut, sesamum etc. The beginner should start with 2 and not more than 5 colonies. A minimum of 2 colonies is recommended because in the event of some mishap, such as the loss of the queen occurring in one, advantage may be taken with the other.

The hive consists of bottom-board, brood chamber, brood chamber frames, super chamber, super chamber frames, top cover, inner cover, and entrance rod. These parts can easily be separated. The

hive may be double walled or single walled. The single walled hive is light and cheap. The most suitable time for commencing bee keeping in a locality is the arrival of the swarming season. Swarming is a natural tendency of bees to divide their colonies under conditions that are generally favourable for the survival of both parent colony and the swarm. This occurs during the late spring or early summer.

**(iii) Honey collection:** Honey is a sweet viscous fluid produced by honeybees mainly from the nectar of the flowers. Honey should have good quality to meet the national and international standards. Qualities such as aroma, colour, consistency and floral sources are important. Proper honey straining and processing are needed to improve the quality of the produce. Honey varies in the proportion of its constituents owing to the differences in the nectar produced by different plants. The nectar collected by bees is processed and placed in comb cells for ripening. During the ripening, sucrose is converted into glucose and fructose by an enzyme called invertase, which is added to it by the bees. Honey is an excellent energy food with an average of about 3500 calories per kg. It is directly absorbed into the human blood stream, requiring no digestion.

## **6.8 Fishery**

Ponds serve various useful purposes, viz., domestic requirement of water, supplementary irrigation source to adjoining crop fields and pisciculture. With the traditional management, farmers obtain hardly 300-400 kg of wild and culture fish per ha annually. However, composite-fish culture with the stocking density of 5000-7500 fingerlings/ ha and supplementary feeding can boost the total biomass production.

- (i) **Pond:** The depth of the pond should be 1.5-2.0 m. This depth will help for effective photosynthesis and temperature maintenance for the growth of zoo and phytoplankton. Clay soils have higher water retention capacity and hence are best suited for fish rearing. Pond water should have appropriate proportion of nutrients, phosphate (0.2-0.4 ppm), nitrate (0.06-0.1 ppm) and dissolved oxygen (5.0-7.0 ppm). Water should be slightly alkaline (pH 7.5-8.5). If the pH is less than 6.5, it can be adjusted with the addition of lime at regular interval of 2-3 days. Higher pH (>8.5) can be reduced with the addition of gypsum. Application of fresh dung may also reduce high pH in the water. Soil of the pond should be tested for N and P content. If the nutrient content is less, nitrogenous fertilizers like ammonium sulphate and urea and phosphatic fertilizer like super phosphate can be added. Organic manures such as FYM and poultry droppings may also be applied to promote the growth of phyto and zooplanktons.
- (ii) **Species of fish:**

- (i) Among the Indian major carps, Catla (*Catla catla*) is the fast growing fish. It consumes a lot of vegetation and decomposing higher plants. It is mainly a surface and column feeder.
- (ii) Rohu (*Labeo rohita*) is a column feeder and feeds on growing fish. It consumes a lot of vegetation and decomposing higher plants. It is mainly a column and surface feeder.
- (iii) Calbasu (*Labeo calbasu*) is a bottom feeder on detritus. Mrigal (*Cirrhinus mrigala*) is also a bottom feeder, taking detritus to large extent, diatoms, filamentous and other algae and higher plants. Common carp (*Cyprinus carpio*) is a bottom feeder and omnivorous.
- (iv) Silver carp (*Hypophthalmichthys molitrix*) is mainly a surface and phytoplankton-feeder and also feeds on micro-plants.
- (v) Grass carp (*Ctenopharyngodon idella*) is a specialized feeder on aquatic plants, cut-grass and other vegetable matter. It is also a fast growing exotic fish.
- (iii) **Composite Fish Culture:** The phytophagous fish (Catla, Rohu and Mrigal) can be combined with omnivorous (Common carp), plankton-feed (Silver carp) and mud-eaters (Mrigal and Calbasu) in a composite fish culture system.
- (iv) **Management:** For higher productivity fish are to be provided with supplementary feeding with rice bran and oilseed cakes. This will enable faster growth and better yield. Each variety of carps could be stocked to 500 fingerlings with the total 5000-8000 per ha. This stocking density will enable to get a maximum yield of 2000 to 5000 kg/ha of fish annually under good management practices.

## 6.9. Sericulture

Sericulture is defined as a practice of combining mulberry cultivation, silkworm rearing and silk reeling. Sericulture is a recognized practice in India. India occupies second position among silk producing countries in the world, next to China. The total area under mulberry is 188 thousand ha in the country. It plays an important role in socio-economic development of rural poor in some areas. In India more than 98% of mulberry-silk is produced from five traditional sericultural states, viz., Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu, and Jammu and Kashmir.

The climatic conditions in India are favourable for luxuriant growth of mulberry and rearing and silkworms throughout the year. The temperature in Karnataka state, major silk producing state in India, ranges from 21.2 to 30 °C. Climatic conditions in Kashmir are favourable to silk worm from May to October.

- (i) **Moriculture:** Cultivation of mulberry plants is called as 'moriculture'. There are about 20 species of mulberry, of which four are commonly cultivated. They are *Morus alba*, *M. indica*,

*M. serrata* and *M. latifolia*. The crop can yield well for 12 years, after which they are pulled out and fresh planting is done. Yield of mulberry leaves is 30-40 t/ha/year.

- (ii) **Silk worm rearing:** There are four types of silk worm viz. (i) Mulberry silk worm – *Bombyx mori* (ii) Eri silk worm – *Philosamia ricini* (iii) Tassar silk worm – *Antheraea mylitta* (iv) Muga silk worm – *Antheraea assami*
- (iii) **Rearing and Maintenance:** The fertilized moth is covered with an inverted funnel or cellulose and eggs are allowed to be laid over a cardboard. Parasites may be removed by brushing the egg masses with a fine brush. This will also enable to obtain a uniform hatch. In a bamboo tray rice husk is spread. Tender chopper mulberry leaves are added to the tray. The hatched out larvae are transferred to the leaves. Leaves are changed after every 2-3 hours during the first 2-3 days. The cocoon is constructed with a single reelable thread of silk. If the moths are allowed to emerge from the cocoons, the silk thread is cut into pieces. Hence the pupa are killed 2-3 days before the emergence of moth and processed. The cocoons required for further rearing are kept separately and moths are allowed to emerge from them.

#### 6.10. Mushroom Cultivation

Mushroom is an edible fungus with great diversity in shape, size and colour. Essentially mushroom is a vegetable that is cultivated in protected farms in a highly sanitized atmosphere. Just like other vegetables, mushroom contains 90% moisture with high in quality protein. Mushrooms are fairly good source of vitamin C and B complex. The protein have 60-70% digestibility and contain all essential amino acids. It is also rich source of minerals like Ca, P, K and Cu. They contain less fat and CHO and are considered good for diabetic and blood pressure patients.

- (i) **Species:** There are three types of mushrooms popularly cultivated in India. They are (i) Oyster mushroom – *Pleurotus sp.* (ii) Paddy straw mushroom – *Volvariella volvacea* (iii) White bottom mushroom – *Agaricus bisporus*

- (ii) **Method of production**

- a. **Oyster Mushroom:** Take fresh paddy straw and cut into small pieces of 3-5 cm length. Soak them in water for 4-6 hours and then boil for half an hour. Drain the water and dry the straw in shade till it is neither too dry nor wet. Take polythene bags of 60 x 30 cm size and make two holes of one cm diameter in the center of the bag such that they face opposite sides. Tie the bottom of the bag with a thread to make a flat bottom. Fill the bag with paddy straw to 10 cm height. Then inoculate with the spawn. Likewise prepare 4-5 layers of straw and spawn alternatively. The last layer ends up in straw of 10 cm height. Keep this in a spawn running room maintained at a temperature of about 22-28 °C and with RH 85-90%. After 15-20 days when the

spawn running is completed, cut open the polythene bag and take it to cropping room and allow it to grow for 7 days and harvest the mushroom. Mushroom yield is around 0.5-1.0 kg/bag.

- b. **Paddy straw Mushroom:** Cut the straw into long pieces of 60-90 cm and soak in water for 12 hours and sterilize 15 minutes. Arrange the straw in bundles. Lay the moistened straw bundles on the slightly raised concrete floor or on wooden platform in layers of four bundles width. Spawn or seed the beds simultaneously in each layer either by broadcasting or placing the grain spawn at different spots. Sprinkle grain dhal over each layer on the spawn. Don't spawn below the topmost layer. Maintain it at 30-35 °C. Harvesting is ready after 25-30 days. Yield is around 1-1.5 kg/bed.
- c. **Button Mushroom:** It requires a complex method of preparing compost, which is used as a substrate for mushroom production. Spawning is done by three methods, viz., surface spawning, layer spawning and trough spawning. Fill the trays with compost and do spawning. After spawning, compost is pressed hard to make it compact. The trays are arranged in the cropping room in tiers and cover with newspaper sheet sprayed with 2% formalin. The temperature of 20-25 °C and RH of 90-95% should be maintained. After spawn running is completed in 15-20 days and do casing. Pin heads appear within 10-15 days after casing. Cropping continues for 60-75 days. Mushrooms can be harvested at button stage. Yield ranges from 6-7 kg/m<sup>2</sup>.

## 6.11. Agroforestry

Agroforestry is a collective name for land use systems and technologies, in which woody perennials (trees, shrubs, palms, bamboos etc) are deliberately combined on the same land-management unit as agricultural crops and/or animals, either in some form of spatial arrangement or in a temporal sequence. In agroforestry systems, there are ecological and economical interactions among different components. That implies that:

- (i) agroforestry normally involves two or more species of plants (or plants and animals) at least one of which is woody perennials;
- (ii) an agroforestry system always has two or more outputs;
- (iii) the cycle of an agroforestry system is always more than one year; and
- (iv) even the simplest agroforestry system is structurally, functionally, and socio-economically more complex than a monocropping system. Agroforestry is important for meeting fodder, fuel wood and small timber of farmers, conserving soil and water, maintenance of soil fertility, controlling salinity and water logging, positive environment impact and alternate land use for marginal and degraded lands. Selection of proper land use systems conserve biophysical resources of non-arable land besides providing day-to-day needs of farmer and livestock within the farming system.

The different commonly followed agro-forestry systems in India are: (1) Agri-silviculture (crops + trees), which is popularly known as farm forestry (2) Agri-horticulture (crops + fruit trees); (3) Silviculture (Trees + pasture + animals); (4) Agri-horti-silviculture (crops + fruit trees + MPTS + pasture); (5) Horti-silvi-pasture (fruit trees + MPTS+ Pasture); (6) Agri-silvi-pasture (crops + trees + Pasture); (7) Homestead agroforestry (multiple combination of various components); (8) Silviculture (trees + honey bees); (9) Agri-pisci-silviculture (crops + fish + MPTS); (10) Pisci-silviculture (Fish + MPTS) etc.

**A. Agri-silvicultural Systems:** This system emphasizes raising of trees and cultivation of field crops and/or fodder crops in the available space between the trees. In arid and semi-arid regions hardy trees like *Prosopis cineraria* (Khejri), *Eucalyptus sp.*, *Acacia tortilis*, *Hardwickia binata* (Anjan), *Azadirachta indica*(Neem), *Ailanthes excelsa*, *Ziziphus jujuba* etc. could be grown along with dry land crops such as pulses (pigeonpea, blackgram), millets (finger millet, sorghum) etc. This is practiced mostly on arable lands, wherein multipurpose trees used for fuel and fodder can be grown with crops in the fields as alley farming. The hedges follow contour and comprise trees and shrubs like *Leucaena* or pigeonpea. Leguminous perennials are more suitable due to fixation of nitrogen.

**B. Agri-horti-silviculture:** In this system fruit trees are grown along with crops and multipurpose trees (MPTs). Under rainfed situation hardy fruit trees like ber, aonla, pomegranate, guava could be grown along with dryland crops like pigeonpea, til, mothbean, mustard etc. Grafted ber (Var., Gola, Seb, Mundiya, Banarasi Kasak) may be planted at 6 x 6 m with 2 plants of subabul in between. Under partial irrigation, Guava, pomegranate, Lemon, Kinnow have been successfully grown at 6 x 5 m along with crop like wheat, groundnut and subabul (200 pl/ha) for quick leaf fodder and fuel wood production. For further protecting fruit crops from desiccating hot summer and cold winter planting of subabul/sesbania at every 2 m apart as wind breaks. Alternate plants of subabul/sesbania could be harvested for quick fodder and fuel wood production every 3rd year. Relative grain yield was 70-85% even in 3rd and 4th year.

**C. Silvi-Pastoral system:** In the silvi-pastoral system, improved pasture species are introduced with tree species. In this system grasses or grass legume mixture is grown along with the woody perennial simultaneously on the same unit of land. In the marginal, sub-marginal and other degraded lands silvipastoral system has been found to be most economic agroforestry system especially in arid and semi-arid regions. It involves lopping trees and grazing understory grasses and bushes in forests or plantations. It helps in reduction of the cost of concentrated feed to animal during lean period. A number of fodder trees like *Leucaena latisiliqua*, *Bauhinia variegata*, *Albizia labbek*, *Albizia amara*, *Moringa olerifera*, *Sesbania sesban*, *S. grandiflora*,



*Hardwickia binata* are identified for different regions of the country for silvi pastoral systems. Trees provide fuel and timber in the extreme dry season and lean periods, animal graze on pastures and feed on the leaves of nutritious trees and shrubs. Multilayered vegetation covers are very effective in controlling run-off and soil loss from erosion prone areas.

- D. Horti-Pastoral system:** It involves integration of fruit trees with pasture. In the degraded arid and semi arid rangeland regimes number of over grazed plants of *Ziziphus nummularis* are found which could be successfully budded with improved variety of ber (viz., Gola, Seb, Umran, Banaras, Kaska) besides planting MPTs like anjan, Subabul, Khejri along grasses and legumes like *Cenchrus*, *Lasiurus*, *Chrysopogon*, *Stylosanthes*, *Sirato* etc.
- E. Agri-silvi-pasture:** It is a combination of agri-silviculture and silvi-pastoral system. In arid degraded lands of Rajasthan, Gujarat and Haryana often dryland crops viz. bajra, moth, urad, til etc. are grown in strips along with grass strips to avoid shifting sand reaching cropped area. MPTs could be introduced both in the pasture strips as well as in the crop strips, which besides protecting the crops from desiccating hot and cold wind would also provide leaf fodder, timber etc. besides pasture when there is a crop failure. Woody plants could be *Acacia senegal*, ber, anjan, neem etc. Grasses like *Cenchrus*, *Lasiurus* and legume *Stylo sp.*
- F. Pastoral silvicultural system:** Integrated crop farming is practiced to meet the requirements of grasses and fodder for livestock. The pastoral silvicultural system is the practice in which grazing is the main component with scattered trees grown in the area. This practice is adopted in semi-arid regions of the country comprising the states of Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Madhya Pradesh. The cultivators leave the fields fallow with existing trees and protect the same. *Dichanthium annulatum* is an important grass under this system. The important planted trees in the system are *Eucalyptus* hybrid, *Casuarina equisetifolia*, *Borassus flabellifera* and *Phoenix sylvestris*. Generally trees are lopped for fuel and fodder. Custard apple, mango, *Zizyphus* and tamarind fruits are used for domestic consumption.

## 6.12. Biogas

A biogas unit is an asset to a farming family. It produces good manure and clean fuel and improves sanitation. Biogas is a clean, unpolluted and cheap source of energy, which can be obtained by a simple mechanism and little investment. The gas is generated from the cow dung during anaerobic decomposition. Biogas generation is a complex biochemical process. The cellulosic material is broken down to methane and carbon dioxide by different groups of microorganisms. It can be used for cooking purpose, burning lamps, running pumps etc.

Selection of a model: The two main designs of biogas plants are the floating gas holder and fixed-dome types. The merits and demerits of each design need to be considered while selecting model.

(i) **Float dome type:** Different models are available in this category e.g., KVIC vertical and horizontal, Pragati model, Ganesh model.

(ii) **Fixed dome type:** The gas plant is dome shaped underground construction. The masonry gasholder is an integral part of the digester called dome. The gas produced in the digester is collected in dome at vertical pressure by displacement of slurry in inlet and outlet. The entire construction is made of bricks and cement. The models available in this category are Janata and Deen-Bandhu.

The selection of a particular type depends on technical, climatological, geographical and economic factors prevailing in a given area.

(i) **Selection of Size:** The size of the biogas plant is decided by the number of family members and the availability of dung. One cubic metre capacity plant will need two to three animals and 25 kg of dung. The gas produced will meet the requirement of a family of 4-6 members. It would suffice to have a 2 cubic metre plant to cater to the needs of a family of 6-10 members.

(ii) **Site selection and management:** The site should be close to the kitchen or the place of use. It will reduce the cost of gas distribution system. It should also be nearer to the cattle shed to reduce the cost of transport of cattle dung. Land should be leveled and slightly above the ground level to avoid inflow or run-off of water. Plant should get clear sunshine during most part of the day. Generation of dung has a direct bearing on the quantity of gas generated. The amount of gas production is considerably higher in summer followed by rainy and winter seasons. Gas production would be maximum at a temperature between 30 to 35°C. If the ambient temperature falls below 10°C gas production is reduced drastically.

(iii) **Biogas slurry:** Slurry is obtained after the production of bio-gas. It is enriched manure. Another positive aspect of this manure is that even after weeks of exposure to the atmosphere, the slurry does not attract fleas and worms.

# LECTURE - 9

## TOOLS FOR DETERMINING PRODUCTION AND EFFICIENCIES IN CROPPING AND FARMING SYSTEM

### 9.1. Cropping Intensity

$$\text{Cropping Intensity} = \frac{\text{Gross cropped area}}{\text{Net cropped area}} \times 100$$

**Example:** Calculate cropping intensity from the following information

- a) Net cultivated area in farm = 10 ha
- b) Cultivated area in *Kharif* (A1)=10 ha, *Rabi* (A2) = 10 ha and *Zaid* (A3)= 10ha

$$\text{Gross cultivated area} = A1+A2+A3= 30 \text{ ha}$$

$$\text{Cropping Intensity} = 30/10 *100= 300 \text{ per cent}$$

### 9.2. Multiple cropping Index (MCI)

$$I=1,2,3, \dots n$$

N= total number of  
crops

ai= area occupied by i<sup>th</sup> crop

A= Total land area available for cultivation

Example: Calculate MCI of the given cropping sequence

- a) Net cultivated area in farm = 10 ha
- b) It is divided into two halves A = 5 ha and B=5ha

|       |            |          |
|-------|------------|----------|
| Block | Kharif (1) | Rabi (2) |
|-------|------------|----------|

|   |           |             |
|---|-----------|-------------|
| A | Rice 5ha  | Mustard 5ha |
| B | Rice 5 ha | Rice 5ha    |

MCI for block A = (A1+A2)/Area available with A \*100

$$= (5+5)/5 *100$$

$$= 200\%$$

MCI for block B= (B1+B2)/ Area available for B \*100

$$= (5+5)/5 *100$$

$$= 200\%$$

MCI for whole farm/ cropping intensity = (A1+A2+B1+B2)/Net cultivated area \*100

$$= 20/10 *100 = 200\%$$

$$\text{Multiple cropping Index} = \frac{\sum_{i=1}^n a_i}{A} \times 100$$

### 9.3. Sustainability yield Index

Example: Calculate the sustainable Index of INM and 100% organic practice and if SD= 1

| Treatment    | 2015 | 2016 | 2017 |
|--------------|------|------|------|
| INM          | 4q   | 5q   | 6q   |
| 100% organic | 2q   | 4q   | 3q   |

$$\text{Sustainability yield Index} = \frac{\text{Mean Y- standard deviation}}{Y \text{ max}}$$

For INM

$$\text{Mean yield} = (4+5+6)/3=5q$$

Standard Deviation = 1 Observed  
 maximum yield = 6q

$$SYI = (5-1)/6 = 0.66$$

For 100% Organic

Mean yield =  $(2+4+3)/3=3q$

Standard Deviation = 1

Observed maximum yield = 4q

$$SYI = (3-1)/4 = 0.5$$

From this INM is more sustainable than 100% organic

#### 9.4. Sustainability value index

Example: Calculate the sustainable value Index of INM and 100% organic practice and if SD= 1

| Treatment    | 2015 | 2016 | 2017 |
|--------------|------|------|------|
| INM          | 10   | 20   | 30   |
| 100% organic | 15   | 10   | 20   |

Average Net profit – Standard deviation

Sustainability Value Index =  $\frac{\text{Average Net profit} - \text{Standard deviation}}{\text{Observed maximum net profit}}$

For INM

Mean net profit =  $(10+20+30)/3=20$  Standard Deviation = 1

Observed maximum net profit = 30

$$SVI = (20-1)/30 = 0.63$$

For 100% Organic

Mean yield =  $(15+10+20)/3=15$  Standard Deviation = 1

Observed maximum yield = 20

$$SVI = (15-1)/20 = 0.7$$

From this 100% is more sustainable than INM in terms of economic returns

### 9.5. B: C Ratio:

$$\text{B: C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

Example: Calculate the B: C ratio if the Net return is Rs 20 and cost of cultivation is Rs10

$$\text{Gross return} = \text{Net return} + \text{Cost of cultivation} = 20+10 =\text{Rs } 30$$

$$\text{Cost of cultivation} = \text{Rs } 10$$

$$\text{B: C ratio} = 30/10= 3$$

If the B: C is >1 (more than) then such system is profitable

### 9.6. Crop equivalent yield

If there are two crops A and B in an intercropping system then

$$\text{Equivalent Yield of system} = \text{Yield of crop A} + \text{Crop A equivalent yield of B}$$

$$\text{Crop A equivalent yield of B} = \frac{\text{Yield of crop B (kg/ha)} \times \text{Price of B}}{\text{Price of crop A}}$$

## LECTURE 10

# SUSTAINABLE AGRICULTURE-PROBLEMS AND ITS IMPACT ON AGRICULTURE, INDICATORS OF SUSTAINABILITY, ADAPTATION AND MITIGATION

### 10.1 Sustainable agriculture

Sustain is derived from a latin word “ Sus” means “from below” and “Tenere” means “ To hold”

- ▶ First rule: Align with natural forces or at least not try to defy them
- ▶ Maintain productivity- Management of resources Useful to the society-Satisfy human needs.

#### **Definition:**

*According to CGIAR*

- ▶ Sustainable Agriculture is the successful management of resources for agriculture to satisfy the changing human needs, while maintaining or enhancing the quality of environment and conserving natural resources

### 10.2 Goals of Sustainable Agriculture

- Environmental health
- Economic efficiency
- Community

### 10.3 Problems and Impact on Agriculture

- Decline in agricultural growth rate
- Static or decline in food production
- Increasing malnutrition
- Shrinkage in net cultivated area
- Increasing environmental pollution
- Depleting groundwater table
- Increase cost of production
- Low farm income
- Increasing unemployment

### 10.4 Indicators of Agricultural Sustainability

- Indicators help us to identify, quantify and evaluate the effects of agriculture

- They provide us a means of measuring the economic, social and environmental impacts of agriculture and to help assess the effectiveness of policies and sustainability of the sector

### **10.5 Criteria for selection of ideal sustainability Indicator**

- Policy relevance- Address the issues of primary concern and that receives highest priority
- Predictable- Allow a forward looking perspective that can promote planning and decisions on issues before they become severe
- Measurable- Decide how it can best be applied in planning and decision making

### **10.6 Indicators of key natural resources in rainfed cropping system**

- Nutrient balance – Organic matter- rate of change, nitrogen cycling and monitoring status of phosphorus, sulphur, potassium and micro-nutrients
- Erosion- Vegetative cover, soil surface cover, sheet and gully erosion
- Soil structure- Infiltration, permeability, stability, water-logging, compaction
- pH-Change, Toxicity-deficiency, Indicator plants
- Energy efficiency- Energy input vis-a-vis energy output of whole agricultural system
- Biological factors- Soil macro/micro flora and fauna, animal health, plant health, pests etc.
- Farm Management Skills- Understanding a good indicator would be the understanding of the farmers of their own technical system
- Productivity, yield and quality- Water use efficiency, pasture composition, maintenance of genetic base

### **10.7 Key dimensions for adaptation and mitigation**

- Mitigation is a technological change and substitution that reduce resource inputs and emissions per unit of output
- Research and development
- Technology and practices
- Infrastructure
- Capacity building
- Improved crop seeds, livestock and fish cultures
- Water use efficiency
- Pest management
- Improved agronomic practices
- Nutrient management



- Agricultural insurance
- Credit support
- Markets
- Access to Information
- Livelihood diversification

# LECTURE – 11

## CONSERVATION AGRICULTURE

### 11.1. Conservation Agriculture strategies in Agriculture

Conservation Agriculture is a sustainable agriculture production system comprising a set of farming practices adapted to the requirements of crops and local conditions of a region, whose farming and soil management techniques protect the soil from erosion and degradation , improve the quality and bio-diversity and contribute to the preservation of the natural resources, water and air, while optimizing yields.

### 11.2. Principles of conservation agriculture

- Continuous minimum mechanical soil disturbance.
- Permanent organic soil cover.
- Diversified crop rotations in case of annual crops or plant associations in perennial crop.

### 11.3. Concept of conservation agriculture:

- Excessive tillage degrades soil in long run.
- If soil is not tilled for many years produce a layer of mulch.
- This favours biological tillage.
- This may increase weed and pest infestation.
- To break the chain of infection crop rotations are adopted in CA additionally helps as biological pumps.

| Conventional Agriculture                      | Conservation Agriculture               |
|-----------------------------------------------|----------------------------------------|
| Excessive mechanical tillage and soil erosion | No-till or drastically reduced tillage |
| High wind and soil erosion                    | Low wind and soil erosion              |
| Residue burning or removal                    | Surface retention of residues          |
| Water infiltration is low                     | Infiltration rate of water is high     |

|                                                                      |                                                                            |
|----------------------------------------------------------------------|----------------------------------------------------------------------------|
| Kills established weeds, but stimulates more weed seeds to germinate | Weeds are a problem in the early stages of adoption but decrease with time |
| Mono-cropping, less efficient rotations                              | Diversified and more efficient rotations                                   |
| Productivity of grains in long run are declining order               | Productivity of grains in long run are in incremental order                |
| Uses ex-situ FYM/Composts                                            | Use in-situ organics/composts                                              |

#### 11.4. Advantages of Conservation Agriculture

- Time saving and thus reduction in labour requirement
- Reduction in costs
- More output per low input
- Organic matter increases
- In soil water conservation
- Improvement in soil structure
- Reduction soil erosion
- Improves carbon sequestration

#### 11.5. Limitations of Conservation Agriculture

- Lack of initial knowledge .
- Initial nervousness to switch from plough based farming.
- Misconception on herbicide usage.

#### 11.6. Constraints for adopting Conservation Agriculture

- Lack of appropriate seeders for small and medium scale farmers.
- Wide spread use of crop residues for livestock, feed and fuel.
- Burning of crop residues.
- Lack of knowledge about the potential of CA to agricultural leaders, extension agents and farmers
- Skilled and scientific manpower.

# **LECTURE -12**

## **HEIA, LEIA AND LEISA AND ITS TECHNIQUES FOR SUSTAINABILITY**

### **Why sustainability**

- Man entered farming with the advancement of civilization.
- He learned to cultivate through trial and error and accumulated lots of traditional knowledge.
- This knowledge was transferred from generation to generation.
- When he realized that the land he cultivated had become unfertile after several years of repeated cultivation he shifted to new land.
- Now, with limited land availability such shifting was not possible.

### **12.1. High External Input Agriculture (HEIA)**

- Limitation in per capita land availability is due to increasing population.
- To confront this pressure of world population explosion we are compelled to join a revolution “Green revolution”.
- This revolution aims at more harvest per unit area and intensification of number of cultivation seasons .

#### **Green revolution practices**

- Use High yielding hybrid seeds
- Susceptible to pests and diseases
- Increased use of synthetic pesticides and herbicides
- More use of nutrients
- Improved irrigation facilities
- Labour intensive
- Mechanization of Agriculture

#### **12.1.1. Advantages of HEIA**

- Agricultural production could be rapidly increased to meet the demand for food for increasing population.
- Malnutrition problem was efficiently managed.
- New improved varieties gave yields within a short period of time.
- Mechanization solves the problem of labour shortage.
- Income and profit margins of the products were increased.

- Productivity of land increased.
- Increased market facilities for production .

### **12.1.2. Disadvantages of HEIA**

- Collapse of environmental balance due to lack of bio-diversity by planting a few cash crops.
- Increase in soil erosion due to constant furrowing by machinery.
- Dependence on imported machinery, chemical fertilizer, pesticides, hybrid seeds and other inputs.
- Extensive use of pesticides disturbed the natural mechanism of controlling pest and diseases as the artificial pesticides kill both pests and their natural enemies.
- Although the need for high capital investment, large scale farmers benefited while small scale farmers who were short of capital ran into debt.
- Use of artificial agro-chemicals adversely affected the soil pH, CEC, soil structure, soil texture and soil organisms.
- Traditional varieties of seeds and their genetic resources faced extinction due to introduction of hybrid varieties.

## **12.2 Low External Input Agriculture (LEIA)**

- It is defined as a production activity that uses synthetic fertilizers or other agro-chemicals below rates commonly recommended
- It does not mean elimination of these materials but yields are maintained by greater emphasis on cultural practices, IPM and utilization of on-farm resources
- It includes maximum utilization of local resource with less dependency on external inputs for agricultural production
- It relies mostly on the inputs from local farm, village or region and deliberate action is taken to ensure sustainability
- The objective of LEISA is to maintain the agricultural production at an optimum level using less external inputs in eco-friendly environment

### **12.2.1. Factors affecting LEISA**

- Maintaining a living soil
- Creating Bio-diversity
- Recycling of resources
- Natural pest management

| <b>HEIA</b>                                                                         | <b>LEIA</b>                                                                                |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Farming pattern depends heavily on external and chemical inputs                     | It relies on the optimal use of natural processes.                                         |
| Focus of agricultural development & research .                                      | Focus is on the sustainability of farming system.                                          |
| There is a great damage to the environment.                                         | Environmentally sound                                                                      |
| The rising costs of agricultural inputs have made farming increasingly unprofitable | Greater emphasis is on the long term sustenance & balance between the profit & livelihood. |
| HEIA depends on the higher production & profit.                                     | Sustainable ecological practices depends on local agro –ecological conditions.             |
| Lack of diversity in the farming practices.                                         | Maintaining diversity.                                                                     |
| Under HEIA system soil quality deteriorates.                                        | LEIA maintains a healthy soil.                                                             |
| There is a lack of use of indigenous technologies.                                  | Best use of indigenous technologies                                                        |

# **LECTURE 13**

## **INTEGRATED FARMING SYSTEM-HISTORICAL BACKGROUND, OBJECTIVES AND CHARACTERISTICS, COMPONENTS OF IFS AND ITS ADVANTAGES**

It is defined as a new type of system in which multiple agricultural productions and development are guided, organized and managed in the light of ecological-economic principles and by using the system engineering approach

IFS works as a system of systems. It ensures that waste from one firm become a resource for another firm

### **13.1. The Specific Objectives are:**

1. To identify existing farming systems in specific areas and assess their relative viability
2. To formulate farming system models involving main and allied enterprises for different farming situations.
3. To ensure optional utilization and conservation of available resources and effective recycling of farm residues within system and to maintain sustainable production system without damaging resources/environment.
4. To raise overall profitability of farm household by complementing main/allied enterprises with other.

### **13.2. Goals of IFS**

1. Provide a steady and stable income rejuvenation/amelioration of the system's productivity and
2. Achieve agro-ecological equilibrium through the reduction in the build-up of pests and diseases, through natural cropping system management and the reduction in the use of chemicals (in-organic fertilizers and pesticides).

### **13.3. Advantages of IFS**

1. **Productivity**- IFS provides an opportunity to increase economic yield per unit area per unit time by intensification of crop and allied enterprises. Time concept by crop intensification and space concept by building up of vertical dimension through crops and allied enterprises are the ways to increase the productivity indicated above.
2. **Profitability**- the system as a whole provides opportunity to make use of the produce /waste materials of one component on another component at least cost. Thus there is reduction in cost of production of the component.

3. **Potentiality and profitability-** in IFS, organic supplementation through effective utilization of byproducts of linked components is done thus providing an opportunity to sustain the potentiality of production base for much longer period.
4. **Balanced food-** in IFS, we link components of varied nature enabling to produce different sources of nutrition from same unit area. This will provide an opportunity to solve the malnutrition problem that exists in the diet of average Indian.
5. **Environmental safety-** In IFS, we use waste material as organic source in different component, decrease the application of herbicide and pesticide. Thus IFS greatly reduces environmental pollution.
6. **Recycling-** IFS establishes its stability due to effective recycling of produces or waste materials at the farm level, thus reducing the cost of cultivation also.
7. **Income round the year-** IFS provides flow of money to the farmer round the year by way of disposal of egg, milk, mushroom, and honey .this will help the resource poor farmers to get away from the clutches of money lenders.
8. **Adoption of new technologies-** availability of money round the year gives an opportunity to the small and marginal farmers to go for the adoption of technologies.
9. **Meeting fodder crisis-** growing of perennial fodder crops in the border and water course is a recommended practice in IFS. This helps in enrichment of soil and supplementation of fodder.
10. **Solving fuel and timber crisis-** In IFS, linking agroforestry appropriately, the production level of fuel and timber can be enhanced without detrimental effect on crop activity in the field level.
11. **Employment generation-** combining crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problem of under employment to a great extent. IFS provide enough scope to employ family labour round the year.
12. **Agro industries-** when once the produce of different components linked in IFS are increased to commercial level there will be surplus for value addition leading to then development of allied agro-industries.
13. **Increasing input efficiency-** IFS provides good scope to use the inputs in different components very effectively leading to greater efficiency and benefits cost ratio.
14. **Increasing standard of living-** higher income as well as availability of different produce for family consumption, it increases the standard of living.

Site specific development of IFS model for different agro-climatic zones

#### **13.4. How to select an enterprise**

- Soil and climatic features of an area
- Social status of the family and social customs in the locality
- Economical condition of farmer



- Economics of proposed IFS and credit facilities
- Farmer's managerial skills
- Household demand
- Institutional infrastructure and technological know how
- Market facilities

## LECTURE 14

# SITE SPECIFIC DEVELOPMENT OF INTEGRATED FARMING SYSTEMS FOR DIFFERENT AGRO-CLIMATIC ZONES (INDIA)

### 14.1 Different IFS models for different Agro –climatic zones

1. **High altitude cold deserts:** Pastures with forestry, goats, angora rabbits and limited settled agricultural crops like millets, wheat, barley and fodder.
2. **Arid and desert region:** Centering mainly in animal husbandary with the camels, sheep and goat with moderate cropping components involving pearl millet, wheat, pulses and fodder
3. **Western and central Himalayas:** Horticultural crops as major component have less intensive agriculture mainly on the hill terraces and slopes with maize, rice, wheat, pulses and fodder crops
4. **Eastern Himalayas:** Primitive crop husbandary with rice, millets, pulses etc. Agro-forestry system is also common. Piggery and poultry are the chief livestock activity.
5. **Indo- Gangetic plains:** Intensive crop husbandary involving rice, wheat, maize, mustard, pulses and livestock inclusive of diary cattle and buffaloes
6. **Central and southern highlands:** Cotton, sorghum, millet, pulses with diary cattle, sheep and goats and poultry are the secondary livestock and animal husbandary enterprises
7. **Western Ghats:** Major activity on plantation crops, cultivation of rice and pulses are the secondary agricultural activity. Cattle, sheep and goats are the livestock components which in most parts are maintained as large herds and allowed to range
8. **Delta and coastal plains:** Rice cultivation along with fish culture, poultry and piggery enterprises, capture fisheries of the marine ecosystem is a specialized enterprise and does not mix with cropping activity

## **LECTURE -15**

# **RESOURCE USE EFFICIENCY AND OPTIMIZATION TECHNIQUES, RESOURCE CYCLING AND FLOW OF ENERGY IN DIFFERENT FARMING SYSTEM**

### **15.1. Efficiency**

- Efficiency in any system is an expression of obtainable output with the addition of unit amount of input.
- The ratio of energy intake and energy of the produced biomass i.e. of input and output is called ecological efficiency. This can be studied at any trophic level.
- Resource use efficiency (fertilizer, water etc) is the output of any crop or anything else per unit of the resource applied under a specified set of soil and climatic conditions.

### **15.2. Land use efficiency**

#### **A. Cultivated Land Utilization Index ( CLUI):**

- Cultivated land utilization Index (Chuang, 1973) is calculated by summing the products of land area to each crop, multiplied by the actual duration of that crop divided by the total cultivated land times 365 days.

- Where, n total number of crops;  $a_i$  area occupied by the  $i$ th crop,  $d_i$ , days that the  $i$ th crop occupied and A = total cultivated land area available for 365 days.
- CLUI can be expressed as a fraction or percentage. This gives an idea about how the land area has been put into use. If the index is 1 (100%), it shows that the land has been left fallow and more than 1, tells the specification of intercropping and relay cropping. limitation of CLUI is its inability to consider the land temporarily available to the farmer for cultivation.

### **B. Fertilizer use efficiency (FUE)**

FUE is the output of any crop per unit of the nutrient applied under a specified set of soil and climatic conditions.

The NUE/FUE can be expressed in several ways.

Mosier *et al.* (2004) described 4 agronomic indices to describe NUE:

1. partial factor productivity (PFP, kg crop yield per kg input applied);
2. agronomic efficiency (AE, kg crop yield increase per kg nutrient applied);
3. apparent recovery efficiency (RE, kg nutrient taken up per kg nutrient applied); and
4. physiological efficiency (PE, kg yield increase per kg nutrient taken up). Crop removal efficiency (removal of nutrient in harvested crop as % of nutrient applied) is also commonly used to explain nutrient efficiency.

### **C. Energy efficiencies**

- Energy efficiency = Energy output (MJ/ ha) / energy input (MJ/ ha)
- Net energy (MJ/ ha) = Energy output (MJ/ ha) - energy input (MJ/ ha)
- Energy productivity (kg/MJ)- output (grain + byproduct (kg/ha) / energy input (MJ/ ha)
- Energy intensity = energy (MJ/ ha) / output (grain + byproduct (kg/ha).

### **C. Water use efficiency**

#### **(i) Crop water use efficiency**

Crop water use efficiency is a ratio between marketable crop yield and water used by the crop in evapotranspiration.

$$WUE \text{ (kg/ha-mm)} = Y/ET_c$$

Where, WUE = Water use efficiency in kg/ha-mm

Y = Marketable crop yield in kg/ha

ET<sub>c</sub> = Crop evapotranspiration in mm

#### **(ii) Field water use efficiency**

Field water use efficiency is a ratio between marketable crop yield and field water supply which includes water used by the plant in metabolic activities, ET and deep percolation losses.

- $WUE \text{ (kg/ha-mm)} = Y/WR$  Where,
- FWUE = Field water use efficiency in kg/ha-mm
- Y= Crop yield in kg/ha
- WR = Water used in metabolic activities, ET and deep percolation losses in mm

**(iii) Weed control efficiency**

[Weed count or dry weight in weedy - weed count or dry weight in a treatment]/weed count or dry weight in weedy

**(iv) Resource use efficiency:**

Resource use efficiency in agriculture is defined to include the concepts of technical efficiency, allocative efficiency and environmental efficiency (Haque 2006).

- Public investment, subsidies and credit for agriculture are used in an efficient manner. There are large scale inter regional as well as inter farm variations in factor productivity due to varying influence of different factors in different regions.
- A number of management factors such as timeliness and method of sowing, transplanting, irrigation and application of right doses of inputs and input mix play an important role in influencing inter-farm variation in crop productivity.
- Growing marginalization and fragmentation of land holdings coupled with rising incidence of informal tenancies and poor rural infrastructure such as road, electricity, markets and education affect factor productivity.
- The availability of good quality irrigation water coupled with flexibility of irrigation and drainage system and appropriate methods of application as well as pricing of irrigation water is crucial for sustainable use of land and water resources.
- **Technical efficiency** is the ability of a firm to produce a given level of output with minimum quantity of inputs under a given technology.
- **Allocative efficiency** is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs.
- **Economic efficiency** is a product of technical and allocative efficiency.
- In one sense, the efficiency of a firm is its success in producing as large an amount of output as possible from given sets of inputs.

- Maximum efficiency of a firm is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output.

### 15.3 Linear Programming :

- The word linear is used to describe the relationship among two or more variables which are directly proportional. For example, doubling (or tripling) the production of a product will exactly double (or triple the profit and the required resources, then it is linear relationship.
- Programming implies planning of activities in a manner that achieves some optimal result with restricted resources.
- It has been widely used to find the optimum resource allocation and enterprise combination.
- Linear programming is defined as the optimization (Minimization or maximization) of a linear function subject to specific linear inequalities or equalities.

### 15.4. Assumptions of Linear Programming

- **Linearity:** It describes the relationship among two or more variables which are directly proportional.
- **Additivity:** Total input required is the sum of the resources used by each activity. Total product is sum of the production from each activity.
- **Divisibility:** Resources can be used in fractional amounts. Similarly, the output can be produced in fractions.
- **Non negativity:** Resources and activities cannot take negative values. That means the level of activities or resources cannot be less than zero.
- **Single value expectations:** Resource supplies, input- output coefficients and prices are known with certainty.

### **15.5 Advantages of Linear Programming :**

- Allocation problems are solved.
- Provides possible and practical solutions..
- Improves the quality of decisions.
- Highlights the constraints in the production.
- Helps in optimum use of resources.
- Provides information on marginal value products (shadow prices).

### **15.6. Limitations of Linear programming**

- Does not consider the effect of time and uncertainty
- No guarantee of integer solutions
- Single valued expectations.
- Linearity
- Consider only one objective for optimization.

## LECTURE -16

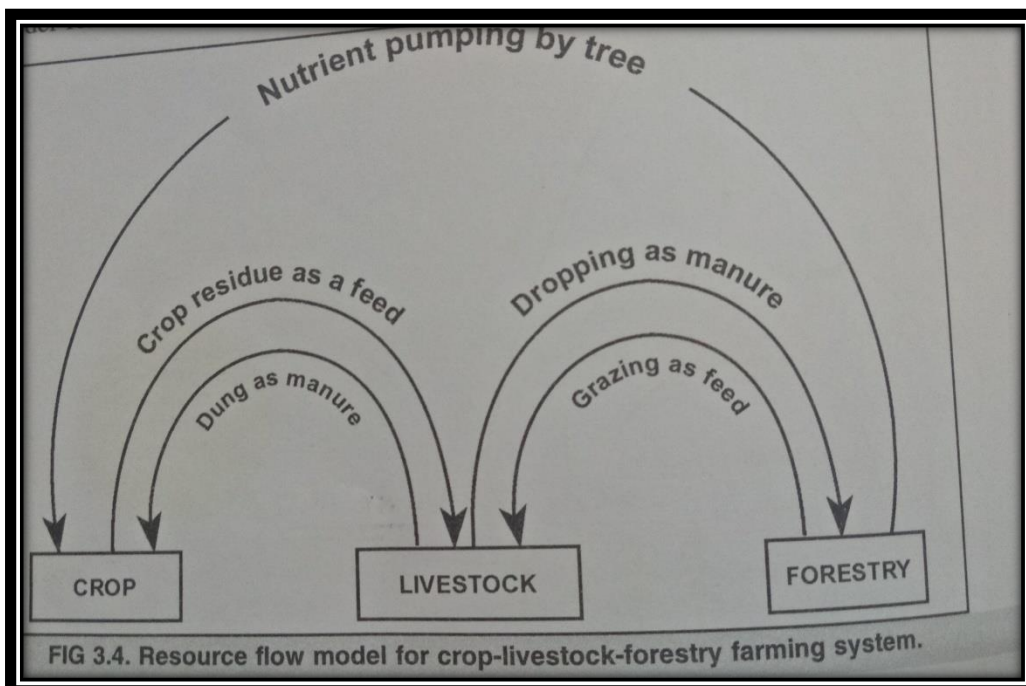
# FLOW OF ENERGY IN DIFFERENT FARMING SYSTEM FARMING SYSTEM AND ENVIRONMENT

### 16.1 Flow of energy in different farming systems

Natural and agricultural ecosystems of which humans are a part are fundamentally a network of energy and mineral flows. Green plants capture solar energy and convert it into chemical energy for use by the biological system using the elements of C, H, O, N, P, K, Ca and Mg. Basic to the survival of humans and other animals are adequate supplies of food that are supplied by the ecosystem.

In agriculture, energy is important in terms of crop production and agro processing for value adding. Since efficient use of the energy resources is vital in terms of increasing production, productivity, competitiveness of agriculture as well as sustainability of rural living, energy auditing is one of the most common approaches to examining energy efficiency and environmental impact of the production system. It enables researchers to calculate output input ratio, relevant indicators and energy use patterns in and agricultural activity. Also, the energy audit provides sufficient data to establish functional forms to investigate the relationship between energy inputs and outputs. Estimating these functional forms is very useful for determining elasticity of inputs on yield and production.

### Flow of energy in different farming system farming system and environment





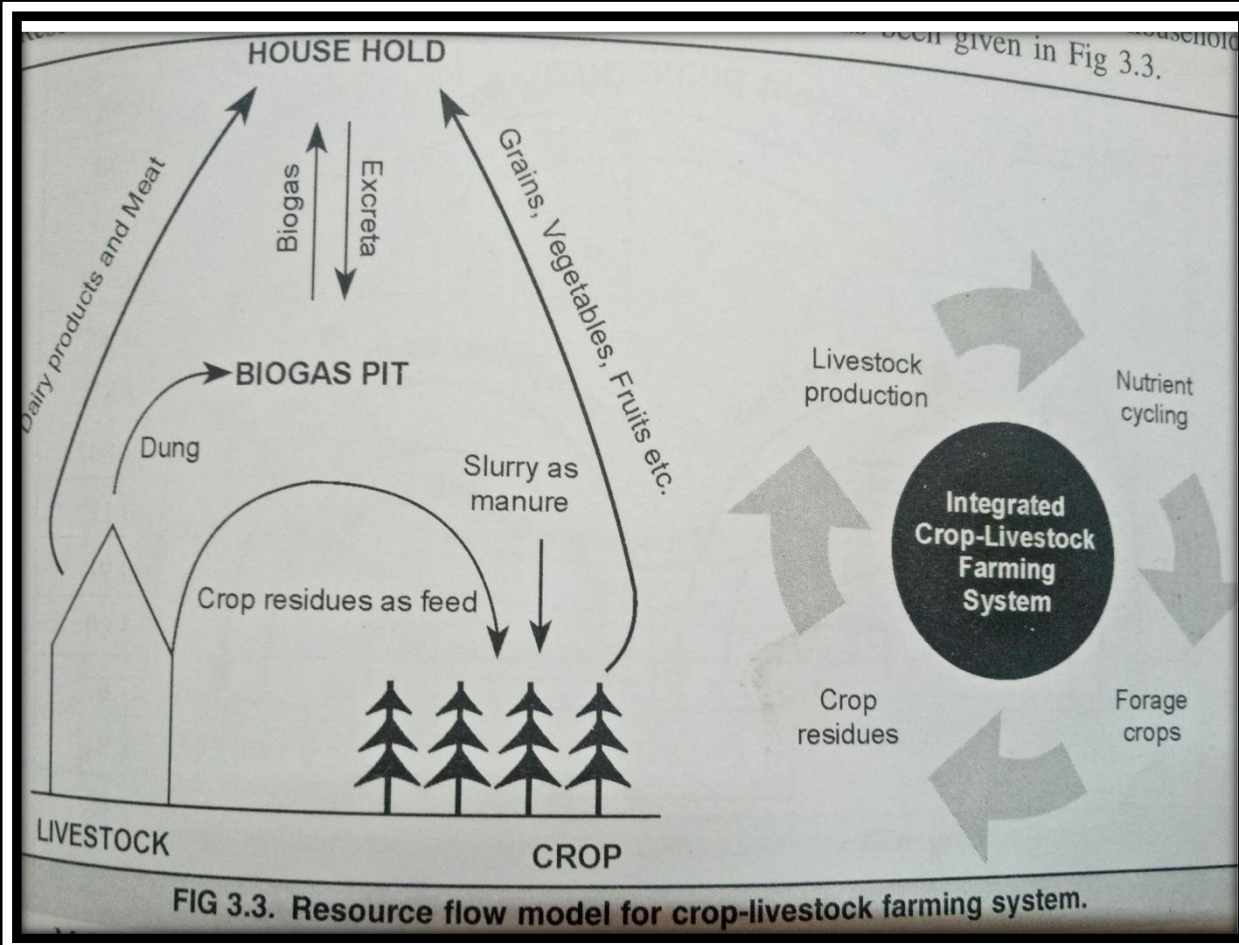


FIG 3.3. Resource flow model for crop-livestock farming system.

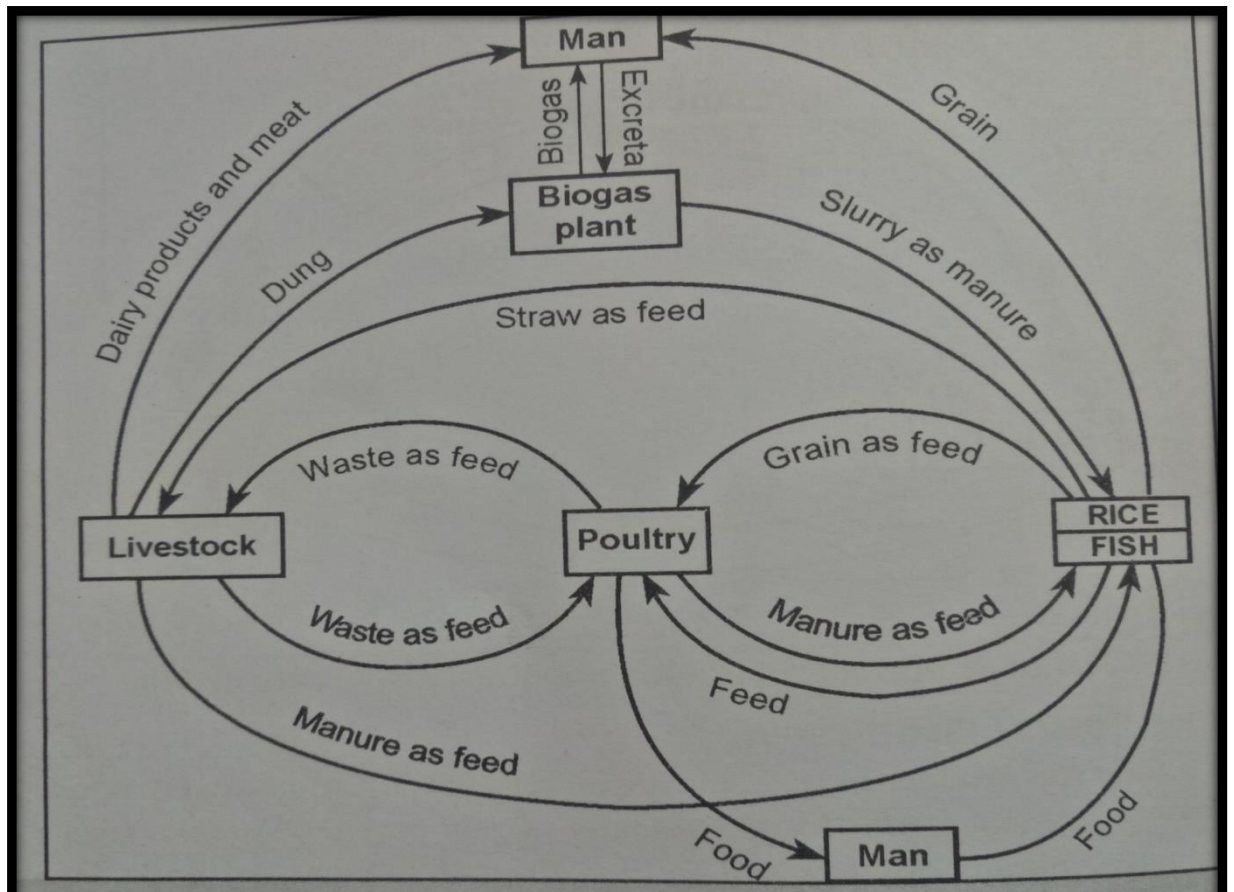


FIG 3.6 Resource flow model for crop-livestock-poultry-fish system.

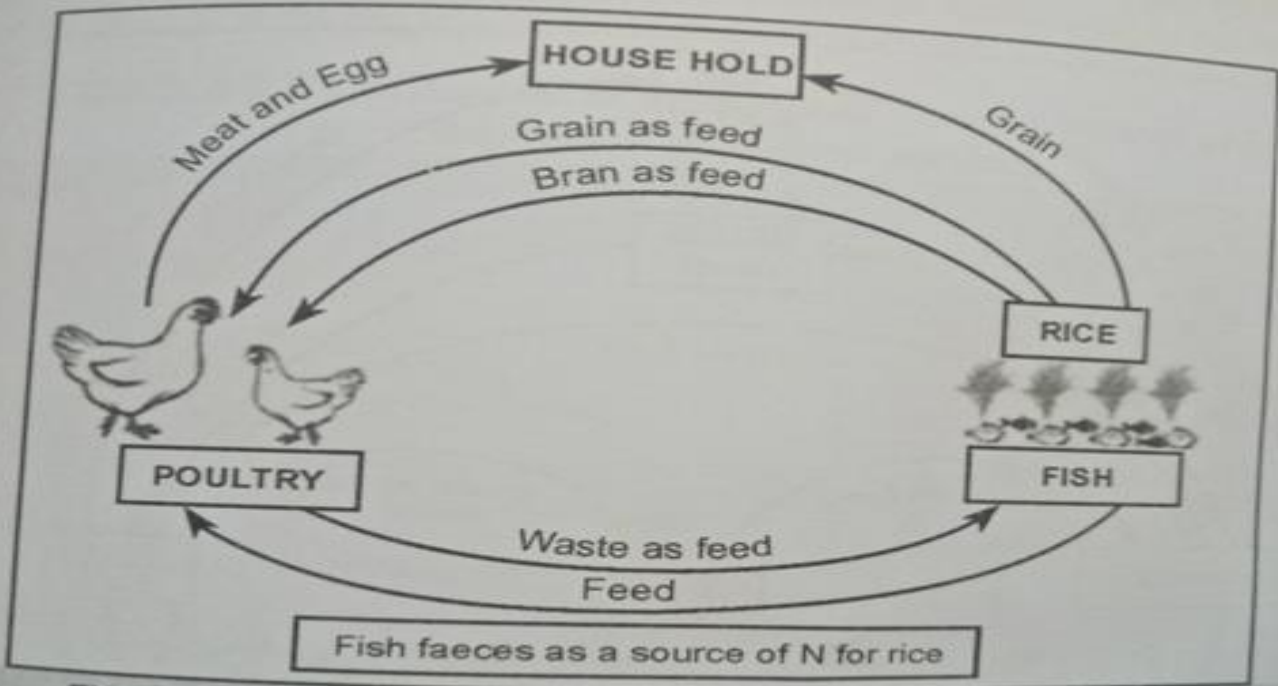


FIG 3.5 Resource flow model for crop-livestock-forestry system.

Energy requirements in agriculture are divided in two groups direct and indirect .Direct energy is required to perform various tasks related to crop production process such as land preparation, irrigation, interculture, threshing, harvesting and transportation of agricultural inputs and farm produce. Indirect energy on other hand consists of the energy used in the manufacture, packaging and tranport of fertilizers, pesticides and farm machinery. Calculating the energy input in agricultural production is more difficult in comparison to the industry sector due to higher number of factors affecting agricultural production. Success of agricultural production is measure by the amount of biomass energy captured in the crop as a result of manipulating plants, land and water while using human and animal power and fossil energy power.

## LECTURE 17 & 18

### ORGANIC FARMING PRINCIPLES AND ITS SCOPE IN INDIA

#### Introduction

India is one of the agricultural based nations, in which more two third of the population pertains to agricultural sector. In India, a large number of farmers and farm labourers are migrating from this sector. This reveals clearly that there is no chance to have satisfactory growth in farming. The existing farming practice is called conventional agriculture which using synthetic and fossil-fuel based inputs like chemical fertilizers, pesticides, herbicides, with a certain extent of mechanical implements for various processes. Prior to 1960s, our country followed traditional farming practice without chemical fertilizers and pesticides. Most of developed countries and some developing nations are returning to organic farming practice during the last two decades due to various problems raised in conventional farming. Organic farming is one among the broad spectrum of production methods that are supportive of the environment. Agriculture remains the key sector for the economic development for most developing countries. It is critically important for ensuring food security, alleviating poverty and conserving the vital natural resources that the world's present and future generations will be entirely dependent upon for their survival and well-being. The essential concept of the practices is "give back to nature", where the philosophy is to feed the soil rather them the crop to maintain the soil health. Therefore, for sustaining healthy ecosystem, there is need for adoption of an alternatives farming system like organic farming.

#### 17.1. Definition

In today's terminology it is a method of farming system which primarily aims at cultivating the land and raising crops in such a way, as to keep the soil alive and ingood health by use of organic wastes (crop, animal and farm wastes, aquaticwastes) and other biological materials along with beneficial microbes (bio fertilizers)to release nutrients to crops for increased sustainable production in an eco-friendlypollution free environment.

According to Lampkin (1990), "Organic agriculture is a production system which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and livestock feed additives".

As per the definition of the USDA study team on organic farming is as follows:

“Organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection”.

In another definition FAO suggested the following:

“Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs”.

National Program on Organic Production (NPOP), India described organic agriculture in the following: “Organic agriculture is a system of farm design and management to create an eco-system which can achieve sustainable productivity without the use of artificial external inputs such as chemical fertilizers and pesticides.”

From the above definitions, it is clear that philosophically organic farming means ‘farming in spirits of organic relationship. In this system everything is connected with everything else. Since organic farming means placing farming on integral relationship with all essential components and it is the totality of these relationships that is the bed rock of organic farming.

In September 2005 in Adelaide, Australia, the General Assembly of IFOAM - Organics International passed a motion to establish a succinct Definition of Organic Agriculture. After almost three years of work by a designated task force, a definition reflecting the four Principles of Organic Agriculture in a succinct way was adopted in Vignola, Italy as follows:

*Organic Agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved."*

## **17.2. Objective of organic farming**

The objectives of organic agriculture are been expressed in the standard document of the International Federation of Organic Agriculture Movement (IFOAM) as follows:

1. To produce food of high nutritional quality in sufficient quantity
2. To work with natural systems rather than seeking to dominate them
3. To encourage and enhance the biological cycles within farming system involving microorganism

4. To maintain and increase the long term fertility of soils
5. To use , as far as possible , renewable resources in locally organized agricultural systems
6. To work, as much as possible, within a closed system with regard to organic matter and nutrient elements.
7. To give all livestock, conditions of life that allow them to perform all aspects of their innate behavior
8. To avoids all forms of pollution that may result from agricultural techniques.
9. To maintain the genetic diversity of the agricultural system and its surroundings, including a safe working environment
10. To consider the wider social and ecological impact of the farming system

### **17.3. Principles of Organic Farming**

To understand the motivation for organic farming, the practices being used and what we want to achieve, it is important to understand the guiding principles of organic agriculture. These principles encompass the fundamental goals and caveats that are considered important for producing high quality food, fiber and other goods in an environmentally sustainable way. The principles of organic agriculture have changed with the evolution of the movement and are now codified. The principles apply to agriculture in the broadest sense, including the way people tend soils, water, plants and animals in order to produce, prepare and distribute food and other goods. They concern the way people interact with living landscapes, relate to one another and shape the legacy of future generations. The principles of organic agriculture serve to inspire the organic movement in its full diversity. They are the roots from which organic agriculture grows and develops. They express the contribution that organic agriculture can make to the world and a vision to improve all agriculture in a global context. The Principles of Organic Agriculture serve to inspire the organic movement in its full diversity.

The International Federation for Organic Agriculture Movement's (IFOAM) definition of Organic agriculture is based on:

- The principle of health
- The principle of ecology
- The principle of fairness and
- The principle of care

Each principle is articulated through a statement followed by an explanation. The principles are to be used as a whole. They are composed as ethical principles to inspire action.

#### **1. Principle of health**

*Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.*

This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems -healthy soils produce healthy crops that foster the health of animals and people.

Health is the wholeness and integrity of living systems. It is not simply the absence of illness, but the maintenance of physical, mental, social and ecological well-being. Immunity, resilience and regeneration are key characteristics of health.

The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings. In particular, organic agriculture is intended to produce high quality, nutritious food that contributes to preventive health care and well-being.

In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

## **2. Principle of ecology**

*Organic Agriculture should be based on living ecological systems and cycles, workwith them emulate them and help sustain them.*

This principle roots organic agriculture within living ecological systems. It states that production is to be based on ecological processes, and recycling. Nourishment and well-being are achieved through the ecology of the specific production environment.

For example, in the case of crops this is the living soil; for animals it is the farm ecosystem; for fish and marine organisms, the aquatic environment. Organic farming, pastoral and wild harvest systems should fit the cycles and ecological balances in nature. These cycles are universal but their operation is site-specific.

Organic management must be adapted to local conditions, ecology, culture and scale. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources.

Organic agriculture should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.

## **3. Principle of fairness**

*Organic Agriculture should build on relationships that ensure fairness with regard tothe common environment and life opportunities.*

Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings.

This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties - farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty.

It aims to produce a sufficient supply of good quality food and other products. This principle insists that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behavior and well being. Natural and environmental resources that are used for production and consumption should be managed in a way that is socially and ecologically just and should be held in trust for future generations. Fairness requires systems of production, distribution and trade that are open and equitable and account for real environmental and social costs.

#### **4. Principle of care**

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

Organic agriculture is a living and dynamic system that responds to internal and external demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being. Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, care must be taken.

This principle states that precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture. Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound.

However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time. Organic agriculture should prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones, such as genetic engineering. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

#### **17.4. Components of organic farming:**

The components of organic farming are discussed in this section:

##### **a. Nutrient management**



- Organic materials such as farm yard manures, biogas slurry, compost, straw or other crop residues, green and brown manures and cover crops can substitute for inorganic fertilizers to maintain the environmental quality.
- In addition, the organic farmers can also use sea weeds and fish manures and some permitted fertilizers like basic slag and rock phosphate.
- The use of organic manures will increase the organic matter content of the soil increasing the water holding capacity. Erosion is reduced by organic manures.
- Crop rotation with legumes adds to soil fertility. Green manure provides the nutrients and improves the soil.
- Application of biofertilizers may be done to supply nutrients to crops as well as to increase the biological activity of the soil.

#### **b. Weed management**

- Compared to conventional farmers, the organic farmers use more of mechanical cultivation of row crops to reduce the weed menace.
- No chemical herbicides are applied as they lead to environmental pollution.

#### **c. Pest management**

- The control of insect pests and pathogens is one of the most challenging jobs in tropical and subtropical agriculture. Here again cultural, mechanical, non-chemical, biological pest management measures are encouraged.
- The conservation of natural enemies of pests is important for minimizing the use of chemical pesticides and for avoiding multiplication of insecticides- resistant pests.
- Botanical pesticides such as those derived from *neem* could be used.
- Selective microbial population pesticides offer particular promise, of which strains of *Bacillus thuringensis*, *Nuclear Polyhedrosis virus* are bright examples.

### **17.5. Advantages of organic farming**

1. Organic manures produce optimal conditions in the soil for high yields and good quality crops.
2. They supply all the nutrients required by the plants (NPK, secondary and micronutrients)
3. They improve plant growth and physiological activities of plants

4. They improve the soil physical properties such as granulation and good tilth, giving good aeration, easy rot penetration and improved water holding capacity.
5. They improve the soil chemical properties such as supply and retention of soil nutrients and promote favorable chemical reactions.
6. They reduce the need for purchased inputs.
7. Most of the organic manures are wastes or byproducts which on accumulation may lead to pollution by way of utilizing them for organic farming, pollution is minimized.
8. Organic manures are considered as complete plant food. Organic matter restores the pH of the soil which may become acids due to continuous application of chemical fertilizers.
9. Organically grown crops are believed to provide healthy and nutritionally superior food for man and animals than those grown with commercial fertilizers.
10. Organically grown resistant to disease and insects and hence only a few chemical sprays or other protective treatments are provided.
11. There is an increasing consumer demand for agricultural products which are free of toxic chemical residues.
12. Organic farming helps to avoid chain reaction in the environment from chemical spray and dusts.
13. Organic farming helps to prevent environmental degradation and can be used to regenerate degraded areas.
14. Since the basis aim is diversification of crops, much more secure income can be obtained than when they rely on only one crop or enterprise.

#### **17.6. Barriers/ Limitations**

1. Initially there may be some barriers which inhibit the farmers from adopting organic farming.
2. Land resources can move freely from organic farming to conventionally farming, they do not move freely in the reverse direction.
3. In changing over to organic farming an initial crop loss generally occurs, particularly if it is rapid.
4. Biological controls may have been weakened or destroyed by chemicals, which may take three or four years to build up.
5. Organic farmers may be afraid to enter the new market without adequate market demand and government support.

## LECTURE -19

### INITIATIVES FOR PROMOTING ORGANIC FARMING

Inability of Indian agriculture to meet the demand for food in the country during the two and a half decades immediately after independence had been a matter of concern at those times. The system of our agriculture based on traditional knowledge and practices handed down from generation to generation could not produce enough to feed the increasing population. The ignominy of our dependence for food on the western developed nations and the politics of food aid practiced by them added to our determination to be self-sufficient in food production by modernizing agriculture. The "green revolution" fulfilled our aspirations by changing India from a food importing to a food exporting nation. Conventional farming had helped India not only to produce enough food for own consumption but also generated surpluses for exports.

- However, the increasing population and income will lead to further increases in demand for food and also for raw materials for industry.
- The first conference of NGOs on organic farming in India was organised by the Association for propagation of Indigenous Genetic Resources (APIGR) in October 1984 at Wardha.
- The year 2000 is very important year for India from organic point of view. The four major happenings were made during the year 2000. These are:
  - The Planning Commission constituted (2000) a steering group on agriculture who identified organic farming as national challenge and suggested that it should be taken in the form of a project as major thrust area for 10th Plan.
  - The group recommended organic farming in NE region, rainfed areas and in the areas where the consumption of agrochemicals is low or negligible.
  - The National Agricultural Policy (2000) recommended promotion of traditional knowledge of a agriculture relating to organic farming and its scientific u[gradations.
  - The Department of Agriculture and Cooperation (DAC), Ministry of Agriculture constituted (2000) a Taskforce on Organic Farming under the chairmanship of shri kunwar ji Bhai Yadav and this task force recommended promotion of organic farming.
  - The Ministry of Commerce launched the National Organic Programme in April 2000 and (APEDA) is implementing the National Programme for Organic Production.

## **NATIONAL PROJECTS ON ORGANIC FARMING**

- The Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, Government of India has launched a new central sector scheme 'National Project on Organic Farming' (NPOF) with an outlay of 57.05 crore for production, promotion and market development of organic farming in the country during 10th Plan on pilot basis.
- The project is operational since 1<sup>st</sup> October, 2004. Its Headquarters is NPOF, Ghaziabad which has six regional centers (RCOFs) at Bengaluru, Bhubaneswar, Hisar, Jabalpur, Imphal and Nagpur.
- The unique feature of this scheme is to promote group certification by capacity building through service provider where the service provider will help organic farmers by providing training, educating on record management, supervising internal control stem, assisting in certification and market access.
- One service provider will be registered with 1500 farmers working in identical geographical condition with similar type of crop. The group certification will reduce cost of certification

## **LECTURE -20**

### **ORGANIC ECOSYSTEM AND THEIR CONCEPTS**

#### **20.1 Introduction**

Organic agriculture is often described as a natural farming system. It is characterised by refraining from chemical-synthetic inputs, like chemical fertilisers and pesticides. It controls undesirable quantities of crop associates by stimulating the self-regulatory capacity of the agro-ecosystem as much as possible, for example by using agro-bio-diversity at different levels of management (farm level, crop species level, variety level) within the organic farming system (IFOAM 2002).

The concept of 'naturalness' as used in the context of organic agriculture not only refers to the avoidance of chemical inputs and the application of agro-ecological principles, but also implies the acknowledgement and appreciation of 'integrity of life'. To be able to further optimise the organic farming system, there is need for varieties that are better adapted to the organic system and that are in compliance with the concept of naturalness. Currently, organic Farmers largely depend on varieties supplied by conventional plant breeders, who use conventional breeding and seed production techniques and develop varieties for farming systems in which inorganic fertilizer and agro-chemicals are widely used. Organic agriculture is not merely a product-oriented farming system and thus requiring certain variety traits related to productivity, but it is also a production-control system that takes the breeding and propagation techniques and strategies into account; these are partly related to the concept of integrity of life.

#### **20.2 SELF-REGULATORY ABILITY OF THE ORGANIC FARM-ECOSYSTEM SYSTEM STABILITY AND YIELD STABILITY**

Although organic agriculture is nowadays known for its avoidance of the use of agro chemicals and its consequent striving for environmental benefits, organic agriculture is more than merely replacing chemical by natural compounds (IFOAM, 2002). In organic agriculture, one does not want to rely on (phytosanitary) agro-chemical intervention because of the application of the concept of the integrity of life at the level of the ecosystem.

##### **20.2.1 SYSTEM STABILITY**

The self-regulatory ability of organic agro-ecosystems can be defined as the capacity to either resist the effects of small and large perturbations or show enough resilience to counter them without high input (chemical protectants) from outside the farm-ecosystem. Such system stability or resilience can often be

found in multi-species agro-ecosystems and is important for risk reduction and yield increase, but also for reducing population densities of hard organisms and increasing densities of beneficial organisms, both in the short and the long run. Organic agriculture bases its sustainable, self-regulatory production system and concept of a farm as an agro-ecosystem. An agro-ecosystem, defined as an ecological within the agricultural context (with inputs, withdrawal of products and interference by farmer) is shaped by the strong interaction between the variations in abiotic and biotic environment, the genetic composition of species involved and the management resources available to the farmer

Each organic farmer has to find his own way in managing site-specific diversity and identifying the correct assemblages of species in time and space) that will best realize through their biological synergism--the self-regulatory capacity of his individual farm-ecosystem. Next to the farm, differences in cultural practices and the knowledge, skills and motivation of each farmer result in specific farming styles, emphasising that the farmer himself is also part of the agro-diversity-complex. More than his conventional colleague who has greater means no control or overrule diversity, an organic farmer has to translate and apply general ecological knowledge to his specific farm situation. given differences in environmental conditions and the socio-economic context of each farm, differences in cultural practices and the knowledge.

### **20.2.2 YIELD STABILITY**

The reliability of an organic farming system depends not only on high yield levels with low inputs, but also largely on yield stability. Although organic farmers may gain relatively more system stability after their conversion period and several years of good farming practices, they still have few external inputs to quickly control or correct farm conditions during the growing season against undesired heterogeneous environmental conditions in time (weather, Climate) and space (soil, topography). Reduced system stability can result in yield reductions and low yield stability. In humid and temperate sea climate areas, like in the Netherlands due to the infection of crops (varieties) by fungal diseases. In years with dry weather conditions, organic farming systems can profit from the higher soil aggregate stability and can in some cases yield higher than the conventional system where organic matter content of the soil is often lower due to the use of mineral fertilizer. The fact that yields fluctuate much more in organic agriculture than in conventional systems, has become one of the most important factors that limit the growth of the organic market share.

This means that more research is needed to further optimise the organic farming system and to understand the different interactions within the farming system, including research on the role of variety

improvements. Selecting the proper variety can contribute to yield stability through different specific traits, but also by more general traits such as flexibility, robustness and buffering capacity. It is in this context of a self-regulatory farming system that the organic sector is developing a concept for improved varieties adapted to organic farming systems.

### **20.3 SOIL MANAGEMENT**

Soil management for organic agriculture stresses the need for efficient soil management in terms of physical, chemical and biological properties of the soil.

#### **20.3.1 DESCRIPTION OF SOIL MANAGEMENT IN ORGANIC FARMING**

Use of organic manure makes the availability of nutrients less controllable. This might result in lower yield stability. On the other hand, in organic systems, often a higher soil organic matter content is observed than in conventional systems. This might partly compensate for the yield limiting effect of the low nutrient availability by increasing the water holding capacity and nutrient retention capacity of soils under organic production. A ic production. Another matter worthy of attention is that in low input system such as organic farming, within field variation might affect yield stability. Most essential in the use of organic fertilizer necessity for active soil organisms, like earthworms, nematodes, collemboles and mycorrhiza to regulate nutrient cycling processes, to make nutrients available to the crops, to make the soil structure and systems and to suppress pests and diseases.

Besides organic and composted manure, crop residue management are also fundamental tools for enhancing soil fertility. Nutrient catch crops, green manure crops, trap crops and crops with a relatively low harvest Index , like cereals , contribute to the the organic matter in the soil after harvest. Integrating these tools and attuning them specific farm, site and soil will be even more important in the future with reduced availability of manure input. This is because, in the ongoing development of organic farming, the aim is to close nutrient cycles within the organic sector and to become independent of sable manure from conventional farming systems. With tightly closed nutrient cycles, nitrogen will be less of a problem than foe instance potassium and phosphorous, because nitrogen can be supplied by growing legumes that live in symbiosis with nitrogen-fixing organisms.

#### **20.3.2 CONSEQUENCES OF ORGANIC SOIL MANAGEMENT FOR VARIETY REQUIREMENTS**

Consequence of the above-described organic soil fertility management is that in such farming systems, plants have to form and maintain a larger and more active root system for nutrient uptake (have to be efficient in acquiring nutrients) and are more dependent on interaction with beneficial soil microorganisms that promote nutrient uptake. Therefore, organic farmers require varieties that are adapted to such specific low(er) input soil management and that are efficient in nutrient and water uptake under organic farming conditions that have adequate root system architecture and can interact with beneficial soil microorganisms. Moreover such varieties need to be efficient in the use of nutrients i.e, produce relatively large amounts of desired products per unit of nutrient and water taken up by the plant. These varieties are directly related to higher yield levels, but indirectly also through optimal growing dynamics-to lower disease, pests and weed population levels.

1. Organic Varieties Need Adaptation to Low(er) and Organic Input Conditions
2. Organic Varieties Need Adequate Root System
3. Organic Varieties Need Large Capacity to Interact With Beneficial Soil Microorganisms

## **20.4 WEED MANAGEMENT**

In organic farming, weed management is directed at preventive measures and timing of cultural weed management practices besides crop rotation and smothering intercrops.

### **20.4.1 DESCRIPTION OF WEED MANAGEMENT IN ORGANIC FARMING**

Weeds are often cited as the most significant problem in organic farming systems they are certainly the problem that most concerns the farmers, who are considering converting their farm from a conventional one into an organic one. The concept of weed management in organic agriculture is: because herbicides are not allowed in organic farming system emphasis is on prevention, decision-making (timine) and control technology: control on organic farms of yield-and quality-limiting weed populations requires strategies that account for long-term effects. This in turn requires knowledge about the population dynamics of weeds over a rotation and about the seed setting of weeds. If weeds are not suppressed in time, they may become very aggressive (competitive) and complete their life cycle thus producing a seed bank for the coming years and the subsequent crops in the rotation.

Preventive measures aim at reducing the supply of weed seeds and multiplication of weed plants and at destroying weed before the crop is sown. Measures can be taken at different levels: farm level (rotation, intercropping, adjusting (uniform and broad) row distances for adequate mechanical management), crop level ( building up tolerance of a crop by optimising the growing conditions) and variety level (genetic characteristics for competitiveness through plant architecture, rapid juvenile



growth. deep rooting or allelopathic exudates). Not only do crops differ in their competitiveness towards weeds, but also within a crop species varieties have been found to differ in competitiveness

#### **20.4.2. CONSEQUENCES OF ORGANIC WEED MANAGEMENT FOR VARIETY REQUIREMENTS**

Weed suppressive ability of varieties can contribute to the self-regulation principle of the organic farming system, especially when under wet weather conditions the mechanical weed control cannot be done in time or is not effective enough causing crease in the labour need for hand weeding Thus, organic farmers require varieties that he juvenile growth and the ability to cover or shade the soil in an early stage of crop development. In general a denser crop canopy , as influenced by canopy architecture , improves the crop ability to compete with the weeds.

Interference of crops with weeds may also involve the production of inhibitory allelopathic substances by living roots or shoots of crops. There are some examples of genetic differences between varieties in growth-restraining effects on very species, but also some results showing that allelopathic potential may result in or yield quality. The latter concluded that the practical importance of breeding for allelopathic substances might be relatively small and that being for more aggressive crops can have more perspectives.

#### **20.5 DESCRIPTION OF PLANT HEALTH, DISEASE AND PEST MANAGE**

The consequences of losses due to pests and diseases in organic farming systems differ considerably, depending on region, crop, farm structure or market demands. In general.yield in organic agriculture are 20 per cent lower due to a lower nitrogen-input and in some cases due to pests and diseases, Further, growth of the organic sector can be supported if the yield stability can be raised by a better control of diseases and pests. As in weed management, disease and pest management in organic farming systems is interwoven with the total with the total cook al lay out of the farming system and the sophisticated use of agro-ecological knowledge aims at enhancing the self-regulatory capacity and building up high tolerance to diseases instead of regulation with chemical protectants. The central concept of plan in organic farming is: good growing conditions and avoidance of stress will enhance t natural tolerance of plants against plant competitors. Occurrence of many plant diseases therefore, be seen not as the cause of inferior growth but as a result of an imbalance between plant and growing conditions, causing an imbalance in metabolism which attracts insect fungi and bacteria. Next to the already described soil fertility with good soil structure water household, diversification strategies, such as wide crop rotations,

mixed or intercropping, shelter and flowering crops for natural predators are essential in Crop health management strategies at farm level. At crop level optimisation of growing conditions include avoidance of a critical period, broader row- and plant distances and optimising nitrogen supply. The tools a farmer can handle differ in relation to soil-borne, airborne and seed-borne diseases.

### **20.5.1 SOIL-BORNE DISEASES**

The concept is that in organic agriculture most soil-borne diseases and pests can be controlled by stimulating bio-diversity in and above the soil, by feeding soil life with organic soil amendments and good soil management and by choosing site-specific crops in a balanced rotation. Although, the power of disease suppressive ability of (organic) soils and soil life is known, more research is needed to be able to use soil life as a management tool to increase the power of soil defence in a more controlled way. More research has been carried out and more experience gained with rotations. Although, the need for crop rotation is also being recognised in conventional farming, organic farming is simply not possible without adequate crop rotation. Success is intimately related to the choice of the right crops in right sequence and in the right frequency suppressing not only populations of soil-borne pests and diseases, but also of weeds and creating a diverse soil life where beneficial organisms also flourish. Most soil-borne, immobile nematodes and *Sclerotium cepivorum* in onion, can be prevented in such organic systems and only in cases where rotation and soil management do not have the desired effect, as during conversion periods and with less or non-specific disease and pests, resistant varieties can offer an additional alternative.

### **20.5.2 AIR-BORNE DISEASES**

In organic or reduced-input farms, root diseases and pests are, generally, less severe than or just as severe as some specific foliar diseases. Foliar diseases are more difficult to control by biological or cultural measures than root diseases, because foliar disease development is much more determined by climatic factors than by antagonistic or parasitic interactions on the leaf surface, while the reverse is true for root disease development. Many foliar diseases and pests are air-borne, so that rotation (diversification in time) plays a limited role, although spatial crop diversification in combination with varietal disease resistances has an effect at a regional scale. The concept is that for most air-borne diseases good crop management will improve the tolerance of a crop. Shortage as well as an overdose of nutrients reduces the tolerance of the crop. Essential in organic farming systems is gaining and maintaining soil fertility (concerning biotic as well as abiotic components), as described before with an active soil life (micro- and macro biota), good soil structure and crop specific manuring for buffering

and resistance to unbalanced plant growth. Another diversification strategy to reduce spreading of air-borne diseases, such as rusts and powdery mildew in cereals and pests, is through mixed cropping and variety mixtures, creating more within-field genetic variation (or the strategy of under-sowing legumes in non-nitrogen fixing crops). Other diversification practices for enlarging the self-regulatory ability of the farm-ecosystem related to crop health include biological control using natural predators. Therefore a farmer has to manage an ecological infrastructure (the total of more or less deliberately introduced non-productive elements) on the farm for shelter and food web, like flower rows, ditches, hedges and even certain weeds or herbs.

Another aspect that has received a lot of attention recently is the mycotoxins produced by *Fusarium* sp on cereal grain. It appears that this problem is not larger in organic agriculture than it is for conventional cereal production. All research that is focused on other strategies than chemical protectants, to improve the tolerance of cereals against *Fusarium*, will also benefit the organic sector.

### **20.5.3 SEED-BORNE DISEASES**

The EU-regulations on organic farming require the use of organically produced seeds and will no longer allow further derogations for the use of conventionally produced seeds by the end of 2003. This encourages even more conventional seed producers to begin seed production under organic conditions and confronts them with the problems of controlling Seed-borne diseases without chemical seed and soil treatments. Organic seeds have to fulfill the regular phytosanitary requirements for seeds, so that the production of seeds with or without low levels of seed-borne diseases requires more knowledge and experience than is currently available.

## LECTURE 21, 22 & 23

### ORGANIC NUTRIENT SOURCES AND ITS FORTIFICATION

#### 21.1. Organic manures

Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition.

Manures can be grouped into bulky organic manures and concentrated organic manures based on concentration of the nutrients.

1. *Bulky Organic manures*- FYM, Compost and Green manure

2. *Concentrated Organic manures*- Oil seed cakes

#### 21.2 BULKY ORGANIC MANURES

##### Advantages of Bulky organic manures

1. They supply plant nutrients including micronutrients,
2. They improve soil physical properties like structure, water holding capacity etc.,
3. They increase the availability of nutrients,
4. Carbon dioxide released during decomposition acts as a CO<sub>2</sub> fertilizer, and
5. Plant parasitic nematodes and fungi are controlled to some extent by altering the balance of Microorganisms in the soil.

##### 21.2.1 Farmacyard Manure (FYM)

The decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle.

FYM Contains 0.5% N, 0.2% P<sub>2</sub>O<sub>5</sub> and 0.5% K<sub>2</sub>O.

Urine contains 1.0% N and 1.35% K<sub>2</sub>O.

N present in urine is mostly in the form of urea which is subjected to volatilization losses. Leaching and volatilization losses can be reduced by following improved method of preparation of farmyard manure.

### **I. Quality and composition of FYM:**

The quality of manure and chemical composition in particular is highly variable depending upon the kind of animal, age and condition of the individual animal, quality and quantity of feed consumed, kind of litter used, collection and storage of manure

1) **Kind of animal:** The quality of manure depends on the class of manure viz., cattle, horse manure. Within the same class, quality varies according to the kind of animal, such as milch cattle, dry cattle, work cattle, breeding bulls etc. By and large the dung and urine from animals, which assimilates less (little) for their maintenance and production, will provide better quality manure.

2) **Age and condition and individual animal:** Growing animals, milch cattle, pregnant or carrying cattle utilize much of the ingredients in the feeds for building up their growing bodies, milk production and for the development of the embryo [calf]. Old or adult animals kept on light work or no work, utilize little from feeds and as such, most of nitrogen is voided through urine and dung. Eventually, the adult old cattle provide better manure.

3) **Quality and quantity of feed consumed:** Nutritious and protein rich feeds like oil cakes enriches the nitrogen content to the resulting manure than the bulky feeds like straw and green grass. Animals fed on concentrated feeds yield better quality manure.

4) **Kind of litter used:** The quality of manure depends to a considerable extent on the nature of litter used. Remnants of leguminous hays (*Bhusa*) give richer manure than usual straws.

5) **Collection of manure:** The method adopted for collection of dung, urine and litter primarily decide the quality of manure as the loss of nutrients particularly nitrogen occurs from the time urine and dung are voided by cattle. The quality of manure depends upon the methods of collection viz., Byre, Lose box and Dry earth systems

a. **Byre system:** Cattle are stalled in a shed with a non absorbent floor provided with necessary slope towards the urine drains. The urine that flows into the drains is collected into a covered tank. From where it is periodically removed and sprinkled on the manure stored in a covered pit. The perfect cleanliness and hygienic conditions of the stalls as well as cattle can be maintained in this system.

b. **Dry earth system:** The floor of the cattle shed is well rammed and compacted. Layers of fine sand, red earth or loamy soil are spread as an absorbent for urine. The wet portions are properly covered with dry layers or any of the above materials and once a week the surface layer is removed and dumped in the manure pit. Available saw dust, paddy husk, groundnut shell, paddy winnowed dust would serve the purpose very well compared to the earth absorbents. This system is popular and extensively adopted in rural parts being cheap, convenient and practicable under the existing rural conditions in India.

6) **Storage of Manure:** During storage the manure undergoes fermentative changes, decomposition which leads to losing its original structure and shape. There are three methods of storage viz., pit method and heap method and covered pit method.

A. **Pit method (Below ground level):** In this method, the manure is stored in a pit with non-absorbent bottom and sides. The pit is provided with a bund at the rim of the pit to prevent the surface run-off of waters during rainy season. The losses also occur in this method due to exposure to sun and rain, but it is relatively a better method than the heap method.

B. **Heap method (Above the ground level):** This is the most common method adopted in Indian villages. Manure is heaped on the ground preferably under the shade of a tree. Ideal procedure is to dump the dung first and to cover it with litter soaked urine. This is further covered with a layer of litter/ash / earth to prevent the loss of moisture and to avoid direct exposure to sun. It is also desirable to put up a small bund around the base of the heap to protect against surface run-off washing out the manurial ingredients. It is beneficial to cover the exposed portion of the heap with Palmyra leaves or any other available material. The maximum losses of nutrients occur in this method of storage, resulting in poor quality manure. Direct exposure to the vagaries of climate such as sunshine and rainfall causes looseness and dryness of manure, which hasten the losses of nutrients and rapid oxidation of organic matter.

C. **Covered pit method:** Of all the methods described, it is the best method. In this method, the bottom and sides of the pit are made non-absorbent by granite stone lining. The pit is also provided with a bund of 1½ feet height to prevent surface flow of water (Rain water) and a suitable cover by way of roofing with locally available materials like Palmyra or phoenix leaves etc., organic matter and nutrient losses can be effectively controlled in this method of storage in order to obtain better quality manure [FYM: 0.68% N - 0.5% P – 1% K].

## **II. Improved methods of handling FYM**

### **A. Trench method of preparing FYM:**

This method has been recommended by C.N. Acharya. Trenches of size 6 m to 7.5 m length, 1.5 m to 2.0 m width and 1.0 m deep are dug. All available litter and refuse is mixed with soil and spread in the shed so as to absorb urine. The next morning, urine soaked refuse along with dung is collected and placed in the trench. A section of the trench from one end should be taken up for filling with daily collection. When the section is filled up to a height of 45 cm to 60 cm above the ground level, the top of the heap is made into a dome and plastered with cow dung earth slurry. The process is continued and when the first trench is completely filled, second trench is prepared. The manure becomes ready for use in about four to five months after plastering. If urine is not collected in the bedding, it can be collected along with washings of the cattle shed in a cemented pit from which it is later added to the farmyard manure pit.

### **Chemical preservatives can also be used to reduce losses and enrich farmyard manure.**

The commonly used chemicals are gypsum and rock phosphate. Gypsum is spread in the cattle shed which absorbs urine and prevents volatilization loss of urea present in the urine and also adds calcium and sulphur. Rock phosphate also acts similarly in reducing losses and also increases phosphorus content.

### **B. Losses during preparation and storage:**

Cow dung and other farm wastes are collected daily and these are accumulated in manure pit in open space for months together. The manure remains exposed to sun and rain during this period. Due to this effect the nutrients are lost in following ways.

#### **i) By leaching:**

Nutrients of manures are water soluble and these are liable to get washed by rain water. The leaching loss of nutrients will vary with the surface exposed, the intensity of rain fall and the slope of the surface on which manure is heaped. The leaching loss may be prevented by erecting a roof over the pit.

#### **ii) By volatilization:**

During storage, the urine and dung are decomposed and considerable amount of ammonia is produced. The ammonia combines with carbonic acid to form ammonium carbonate and bicarbonate, which are rather unstable and gaseous ammonia may be readily liberated and passes into atmosphere.

### ***Ways to minimize losses from FYM during handling***

- 1) Adopt trench method for handling
- 2) Use of Gobar gas plant
- 3) Adopting covered method of storing FYM
- 4) Adoption of BYRE system in collection of FYM
- 5) Proper field management of FYM
- 6) Chemical preservatives: 1) Gypsum 450 g to 900 g of rock phosphate per day per animal in the cattle shed. 2) rock phosphate.

#### **21.2.2 Sheep and Goat Manure**

The dropping of sheep and goats contain higher nutrients than farm yard manure and compost. On an average, the manure contains 3% N, 1% P<sub>2</sub>O<sub>5</sub> and 2% K<sub>2</sub>O. It is applied to the field in two ways. The sweeping of sheep or goat sheds are placed in pits for decomposition and it is applied later to the field. The nutrients present in the urine are wasted in this method. The second method is sheep penning, wherein sheep and goats are allowed to stay overnight in the field and urine and fecal matter is added to the soil which is incorporated to a shallow depth by running blade harrow or cultivator.

#### **21.2.3 Poultry Manure**

The excreta of birds ferments very quickly. If left exposed, 50% of its nitrogen is lost within 30 days. The average nutrient content is 3.03% N, 2.63% P<sub>2</sub>O<sub>5</sub> and 1.4% K<sub>2</sub>O.

#### **21.2.4 Compost**

A mass of rotted organic matter made from waste is called compost.

The compost made from farm waste like sugarcane trash, paddy straw, weeds and other plants and other waste is called farm compost. The average nutrient content of farm compost is 0.5% N, 0.15% P<sub>2</sub>O<sub>5</sub> and 0.5% K<sub>2</sub>O. The nutrient value of farm compost can be increased by application of superphosphate or rock phosphate at 10 to 15 kg/t of raw material at the initial stage of filling the compost pit.



The compost made from town refuses like street sweepings and dustbin refuse is called town compost. It contains 1.4 % N, 1.00 % P<sub>2</sub>O<sub>5</sub> and 1.4 % K<sub>2</sub>O.

Farm compost is made by placing farm wastes in trenches of suitable size, say, 4.5 m to 5.0 m long, 1.5 m to 2.0 m wide and 1.0 m to 2.0 m deep. Farm waste is placed in the trenches layer by layer. Each layer is well moistened by sprinkling cow-dung slurry or water. Trenches are filled up to a height of 0.5 m above the ground. The compost is ready for application within five to six months.

Enrichment of compost using low cost N fixing and phosphate solubilizing microbes is one of the possible ways of improving nutrient status of the product. It could be achieved by introducing microbial inoculants, which are more efficient than the native strains associated with substrate materials. Both the nitrogen fixing and phosphate solubilising microbes are more exacting in their physiological and ecological requirements and it is difficult to meet these requirements under natural conditions. The only alternative is to enhance their inoculums potential in the composting mass.

Studies conducted at IARI, New Delhi, showed that inoculation with *Azotobacter*/*Azospirillum* and phosphate solubilising culture in the presence of 1% rock phosphate is a beneficial input to obtain good quality compost rich in N (1.8%). The humus content was also higher in materials treated with microbial inoculants.

### **A) Methods of composting**

In **Coimbatore method**, composting is done in pits of different sizes depending on the waste material available. A layer of waste materials is first laid in the pit. It is moistened with a suspension of 5-10 kg cow dung in 2.5 to 5.0 l of water and 0.5 to 1.0 kg fine bone meal sprinkled over it uniformly. Similar layers are laid one over the other till the material rises 0.75 m above the ground level. It is finally plastered with wet mud and left undisturbed for 8 to 10 weeks. Plaster is then removed, material moistened with water, given a turning and made into a rectangular heap under a shade. It is left undisturbed till its use.

In the **Indore method** of composting, organic wastes are spread in the cattle shed to serve as bedding. Urine soaked material along with dung is removed every day and formed into a layer of about 15 cm thick at suitable sites. Urine soaked earth, scraped from cattle sheds is mixed with water and sprinkled over the layer of wastes twice or thrice a day. Layering process continued for about a fortnight. A thin layer of well

decomposed compost is sprinkled over top and the heap given a turning and reformed. Old compost acts as inoculum for decomposing the material. The heap is left undisturbed for about a month. Then it is thoroughly moistened and given a turning. The compost is ready for application in another month.

In the **Bangalore method of composting**, dry waste material of 25 cm thick is spread in a pit and a thick suspension of cow dung in water is sprinkled over for moistening. A thin layer of dry waste is laid over the moistened layer. The pit is filled alternately with dry layers of material and cow dung suspension till it rises 0.5 m above ground level. It is left exposed without covering for 15 days. It is given a turning, plastered with wet mud and left undisturbed for about 5 months or till required.

In Coimbatore method, there is anaerobic decomposition to start with, following by aerobic fermentation. It is the reverse in Bangalore method. The Bangalore compost is not so thoroughly decomposed as the Indore compost or even as much as the Coimbatore compost, but it is bulkiest.

#### NADEP method of composting

The NADEP method of organic composting was developed by a Gandhian worker called Narayan Deotao Pandharipande of Maharashtra (Pusad).

#### **Description**

This method of making compost involves the construction of a simple, rectangular brick tank with enough spaces maintained between the bricks for necessary aeration. The recommended size of the tank is 10 ft (length) x 5 ft (breadth) x 3 ft (height). All the four walls of NADEP tank are provided with 6// vents by removing every alternate brick after the height of 1ft. from bottom for aeration. Tank can be constructed in mud mortar or cement mortar.

#### **Establishment activities**

- Raw materials required for filling NADEP tank:
- Agricultural waste (Dry & green) – 1350-1400 kgs.
- Cattledung or biogas slurry – 98 – 100 kgs.
- Fine sieved soil – 1675 kgs.
- Water – 1350-1400 litres.

The important technique in the manufacture of NADEP compost is that the entire tank should be filled in one go, within 24 hours and should not go beyond 48 hours, as this would affect the quality of the compost. Thatched roof

Before filling, the tank is plastered by dilute cattle dung slurry to facilitate bacterial activity from all four sides. It is also filled in definite layers each layer consisting of the following sub layers.

#### **Sub-layer-1**

4 to 6// thick layer of fine sticks, stems, (To facilitate aeration) followed by 4 to 6// layer of dry and green biomass.

#### **Sub-layer-2**

4 kgs. Cow dung is mixed with 100 litres of water and sprinkled thoroughly on the agricultural waste to facilitate microbial activity.

#### **Sub-layer-3**

60 kgs. of fine dry soil is spread uniformly over the soaked biomass for moisture retention and acts as a buffer during biodegradation. Thus the proportion of organic materials for each layer is 100 kgs. organic biomass: 4kgs. cowdung + 100 litres water+60 kgs soil. In this way, approximately 10 -12 layers are filled in each tank. After filling the tank, biomass is covered with 3// thick layer of soil and sealed with cow dung +mud plaster.

#### **Maintenance**

After 15-30 days of filling the organic biomass in the tank gets automatically pressed down to 2 ft. The tank is refilled by giving 2-3 layers over it and is resealed. After this filling the tank is not disturbed for 3 months except that it is moistened at intervals of every 6-15 days. The entire tank is covered with a thatched roof to prevent excessive evaporation of moisture. Under no circumstances should any cracks be allowed to develop. If they do, they should be promptly filled up with slurry.

Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil.

As a result of these improvements, the soil:

- (i) becomes more resistant to stresses such as drought, diseases and toxicity;
- (ii) helps the crop in improved uptake of plant nutrients; and
- (iii) possesses an active nutrient cycling capacity because of vigorous microbial activity.

These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers.

### **Basic rules are important for the production of good quality compost**

1. The purpose of composting is to convert organic matter into growth promoting substances, for sustained soil improvement and crop production.

2. The organic matter is partially decomposed and converted by microbes. These microbes require proper growth conditions, for their activity i.e moisture content:

50% and 50% aeration of total pore space of the composting material. This is achieved through stacking and occasional turning over. Microbes also need sufficient nitrogen for synthesizing their body cells [the optimum C:N ratio of the composting material is 20:1 to 30:1]

3. Soil microorganisms constitute sufficiently to the decomposition of organic matter through their continuous activities. The majority of these soil animals provide optimal conditions in their digestive track for their synthesis of valuable permanent humus and stable soil crumbs. A typical compost earthworm is *Eisenia foetida*.

4. Certain additives accelerate the conversion and improve the final product. The materials such as lime, earth, gypsum, rock phosphate act as effective additives.

The addition of nitrogen (0.1 to 1 %) is important in case of large C:N ratio of the composting material. Addition of lime (0.3 to 0.5 %), if sufficient lime is not present. The preparation of compost takes 2-3 months. The composition of compost varies with in wide limits.

### **Advantages of Composting**

- Volume reduction of waste.
- Final weight of compost is very less.
- Composting temperature kill pathogen, weed seeds and seeds.
- Matured compost comes into equilibrium with the soil.
- During composting number of wastes from several sources are blended together.
- Excellent soil conditioner
- Saleable product
- Improves manure handling
- Redues the risk of pollution

- Pathogen reduction
- Additional revenue.
- Suppress plant diseases and pests.
- Reduce or eliminate the need for chemical fertilizers.
- Promote higher yields of agricultural crops.
- Facilitate reforestation, wetlands restoration, and habitat revitalization efforts by amending contaminated, compacted, and marginal soils.
- Cost-effectively remediate soils contaminated by hazardous waste.
- Remove solids, oil, grease, and heavy metals from stormwater runoff.
- Capture and destroy 99.6 percent of industrial volatile organic chemicals (VOCs) in contaminated air.
- Provide cost savings of at least 50 percent over conventional soil, water, and air pollution remediation technologies, where applicable.

### **Drawbacks of Using Composts**

Agricultural use of composts remains low for several reasons:

- The product is weighty and bulky, making it expensive to transport.
- The nutrient value of compost is low compared with that of chemical fertilizers, and the rate of nutrient release is slow so that it cannot usually meet the nutrient requirement of crops in a short time, thus resulting in some nutrient deficiency
- The nutrient composition of compost is highly variable compared to chemical fertilizers.
- Agricultural users might have concerns regarding potential levels of heavy metals and other possible contaminants in compost, particularly mixed municipal solid wastes. The potential for contamination becomes an important issue when compost is used on food crops.
- Long-term and/or heavy application of composts to agricultural soils has been found to result in salt, nutrient, or heavy metal accumulation and may adversely affect plant growth, soil organisms, water quality, and animal and human health

#### **21.2.5 Vermicompost**

Vermicompost is the use of earthworms for composting organic residues. Earthworms can consume practically all kinds of organic matter. Earthworms have the capacity to eat as much matter as their own weight and produce the same amount of manure per day in the form of castings. It has become imperative to adopt earthworm farming for sustainable agricultural production and for the economic prosperity of the vermicompost offers the following advantages:

- Can convert 1000 tonnes of moist organic matter into 400 tons of high value compost

- Castings or excreta of earthworms are rich in nutrients and bacterial and actinomycetes population

**The potential benefits include:**

- Reduction of noxious qualities of a wide variety of organic waste, elimination of smell, reduction of harmful microorganisms
- Production of marketable organic fertilizer
- Production of aqua life, birds and animal food or even human food by drying earthworms
- Additional benefit to the farmers
- Increases soil fertility and bacterial activity in the soil
- Increases micro grains in the soil and enhances water absorption capacity
- Helps the plant root get air easily
- Increases plant resistance to pests, fungus and other diseases

**21.2.6 Vermiwash**

- Liquid fertilizer collected over passage of water through a column of worms in action useful as foliar spray.
- Collection of excretory products and mucus secretion of earthworms along with micro nutrients from solid organic molecules.

**Feed ingredients**

Cow dung and agro wastes in the ratio of 1:1 to 1:3 may be mixed and allowed to pre decompose for about 2 weeks in a separate tank adjacent to the vermicompost tank, before being fed to the earthworms.

**Process**

Ideal tank size for small scale vermicompost production is 10' x 6' x 2.5' (150 cu .ft.)

- Additional benefit to the farmers
- Increases soil fertility and bacterial activity in the soil
- Increases micro grains in the soil and enhances water absorption capacity
- Helps the plant root get air easily
- Increases plant resistance to pests, fungus and other diseases

**Conversion:** One kilogram of worms numbering about 600 to 1000 can convert 25 to 45 kg. of wet waste per week. The compost recovery would be around 25 kg per week under well managed conditions.

**Harvest:** The total decomposition may take about 75 – 100 days depending on various factors. Therefore one tank may be used to 4 to 5 times in a year for vermicompost. A few days before the harvest watering of the tank are discontinued to allow migration of worms towards the bottom of the bed. The compost is then

transferred outside without disturbing the bed and heaped on a plain open surface. The compost is sieved through a 3 mm mesh and then packed in gunnies.

### 21.2.7 Green Manuring

It is a practice of ploughing in the green plant tissues grown in the field or adding green plants with tender twigs or leaves from outside and incorporating them into the soil for improving the physical structure as well as fertility of the soil. It can be defined as a practice of ploughing or turning into the soil, undecomposed green plant tissues for the purpose of improving the soil fertility.

The object of green manuring is to add an organic matter into the soil and thus, enrich it with 'N' which is most important and deficient nutrient.

**Types of green manuring:** There are two types of green manuring:

**1. Green manuring in-situ:** When green manure crops are grown in the field itself either as a pure crop or as intercrop with the main crop and buried in the same field, it is known as Green manuring In-situ. E.g.: Sannhemp, Dhaicha, Pillipesara, Shervi, Urd, Mung, Cowpea, Berseem, Senji, etc.

These crops are sown as:

i) **Main crop:** This practice is adopted only on very poor sandy soils as a preliminary to profitable rotations, or in the programme of reclaiming saline and alkaline soils.

ii) **Inter row sown crop:** The quick growing green manure crops are sown along with the main crop between the lines of the crop. Such green manure crops are dhaincha intercropped with paddy, sunnhemp, cowpea in between rows of irrigated crop.

iii) **On bare fallow,** depending upon the soil and climatic conditions of the region.

**2. Green leaf manuring:** It refers to turning into the soil green leaves and tender green twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest area. E.g.: Glyricidia, wild Dhaicha, Karanj.

**Characteristics/desirable qualities of a good manuring:**

1. Yield a large quantity of green material within a short period.
2. Be quick growing especially in the beginning, so as to suppress weeds.

3. Be succulent and have more leafy growth than woody growth, so that its decomposition will be rapid
4. Preferably is a legume, so that atm. 'N' will be fixed.
5. Have deep and fibrous root system so that it will absorb nutrients from lower zone and add them to the surface soil and also improve soil structure.
6. Be able to grow even on poor soils.

**Stage of green manuring:** A green manuring crop may be turned in at the flowering stage or just before the flowering. The majority of the G.M. crops require 6 to 8 weeks after sowing at which there is maximum green matter production and most succulent.

**Advantages of green manuring:**

1. It adds organic matter to the soil and stimulates activity of soil micro-organisms.
2. It improves the structure of the soil thereby improving the WHC, decreasing run-off and erosion caused by rain.
3. The G.M. takes nutrients from lower layers of the soil and adds to the upper layer in which it is incorporated.
4. It is a leguminous crop, it fixes 'N' from the atmosphere and adds to the soil for being used by succeeding crop. Generally, about 2/3 of the N is derived from the atmosphere and the rest from the soil.
5. It increases the availability of certain plant nutrients like P<sub>2</sub>O<sub>5</sub>, Ca, Mg and Fe.

**Disadvantages of green manuring:**

1. Under rain fed conditions, the germination and growth of succeeding crop may be affected due to depletion of moisture for the growth and decomposition of G.M.
2. G.M. crop inclusive of decomposition period occupies the field least 75-80 days which means a loss of one crop.
3. Incidence of pests and diseases may increase if the G.M. is not kept free from them.
4. Application of phosphatic fertilizers to G.M. crops (leguminous) helps to increase the yield, for rapid growth of Rhizobia and increase the 'P' availability to succeeding crop.

**Desirable characters of green manuring:**

1. Multipurpose use, short duration, fast growing, high nutrient accumulation ability.



2. Wide ecological adaptability, tolerance to shade, flood, drought and adverse temperatures and efficient in use of water.
3. Early onset of biological N-fixation, high N accumulation rates, timely release of nutrients and high N sinks in underground plant parts
4. Photoperiod insensitivity, high seed production, high seed viability.
5. Ease in incorporation, ability to cross inoculate or responsive to inoculation, pest and disease resistance.

**Some of the common shrubs and trees used as green leaf manures are the following:**

Weeds also can be used as green manure

*Casia auriculata, Derris indica, Ipomea cornea, Thespesia populnea, Azardicta indica, glyricidia maculate, Leucaena leucocephala, calotropis gigantean, delonix regia, Delonix elata, Jatropha gossipifolia, Cassia tora, Cassia occidentalis, Tephrosia pupurea, Tephrosea candida, Dodonea viscosa, Hibiscus viscosa, Vitex negundo.*

**Non conventional green manures:**

These are leguminous or non – leguminous annuals, shrubs and trees, capable of providing large biomass and can supply considerable quantity of plant nutrients. Initial setback may be seen in crops after the incorporation of organic residues with wide C:N ratio, high lignin content which resist easy decomposition and release of higher proportion of organic acids during decomposition process. This early adverse effect on the establishment of young seedlings might have discouraged the farmers in using those non conventional green biomass as manures in agriculture. This could be overcome by a small extra addition of N or proper pre treatment, with suitable microbial inoculants.

**Choice of green manure crop:**

**Criteria for selection of plants-**

| <b>Criteria</b>         | <b>Effects</b>                                                           |
|-------------------------|--------------------------------------------------------------------------|
| High biomass production | Mobilization of nutrients from and into vegetation; suppression of weeds |

|                                              |                                                                                                                                       |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| Deep rooting system                          | Pumping up of weathered and / or leached nutrients from soil layers not occupied by roots of main crop.                               |
| Fast initial growth                          | Quick soil cover for effective soil protection; suppression of weeds                                                                  |
| More leaf than wood                          | Easy decomposition of organic matter                                                                                                  |
| Low C:N ratio                                | Leading to enhanced availability of nutrients for succeeding crops; easy to handle during cutting and/or incorporation in to the soil |
| Nitrogen fixing                              | Increased nitrogen availability                                                                                                       |
| Good affinity with mychorriza                | Mobilization of phosphorus leading to improved availability for crops                                                                 |
| Efficient water use                          | Possibility to grow after main cropping season on residual moisture or with less rainfall                                             |
| Non –host for crop related pests and disease | Decrease in pest and disease populations                                                                                              |
| No rhizomes                                  | Controllable growth                                                                                                                   |
| Easy and abundant seed formation             | Propogation in farmers field                                                                                                          |
| Useful by products – fodder and wood         | In tegration of animal husbandry and forestry                                                                                         |

### **Stages of incorporation:**

Best stage of incorporation is flowering stage. No definit stage can be fized for green leaf manuring. The plants used for green leafy manuring should be incorporated into soil before they mature or attain woody nature.

### **Time of incorporation:**

The success of green manureing depends on the correct time of trampling green matter into the soil and giving sufficient interval before sowing or planting the crop. After incorporation sufficient time is allowed for decomposition to take place and only after this, the main crop is sown or planted. Usually about six to eight weeks time is found to be sufficient for the decomposition.

### Decomposition of green manure:

Mineralization of organic matter (OM)

Wide C:N ratio 50:1

Close C:N ratio 30:1 or 20:1

### Regions not suitable for green manuring

The use of green manures in dry farming areas in arid and semi arid regions receiving less than 625 mm annual rainfall is, as a rule, impracticable. In such areas only one crop is raised, as soil moisture is limited. The dry farming areas are located in Punjab, MS, Karnataka, Rajasthan, MP and Gujarath specifically Kutch and Saurashtra divisions. On very fertile soils with good physical conditron, it is not advisable to use green manures as part of the regular rotations.

In areas where rabi crops are raised on conserved soil moisture due to lack of irrigation facilities, it is not practicable to adopt green manuring. Such areas are located on a large scale in MP, UP, Rajasthan and Bihar. If green manuring is followed in these areas, there is danger of incomplete decomposition of the green matter, and as such less moisture for succeeding crop.

### 21.2.8 Biofertilizers

Biofertilizers are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants' uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants.

Use of biofertilizers is one of the important components of integrated nutrient management, as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers. They can be grouped in different ways based on their nature and function.

| No.                                        | Groups      | Examples                                                                     |
|--------------------------------------------|-------------|------------------------------------------------------------------------------|
| <b>N<sub>2</sub> fixing Biofertilizers</b> |             |                                                                              |
|                                            | Free-living | <i>Azotobacter, Beijerinckia, Clostridium, Klebsiella, Anabaena, Nostoc,</i> |
|                                            | Symbiotic   | <i>Rhizobium, Frankia, Anabaena azollae</i>                                  |

|                                             |                                |                                                                                                                                          |
|---------------------------------------------|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
|                                             | Associative Symbiotic          | <i>Azospirillum</i>                                                                                                                      |
| <b>P Solubilizing Biofertilizers</b>        |                                |                                                                                                                                          |
|                                             | Bacteria                       | <i>Bacillus megaterium</i> var. <i>phosphaticum</i> , <i>Bacillus subtilis</i><br><i>Bacillus circulans</i> , <i>Pseudomonas striata</i> |
|                                             | Fungi                          | <i>Penicillium sp</i> , <i>Aspergillus awamori</i>                                                                                       |
| <b>P Mobilizing Biofertilizers</b>          |                                |                                                                                                                                          |
|                                             | Arbuscular mycorrhiza          | <i>Glomus sp.</i> , <i>Gigaspora sp.</i> , <i>Acaulospora sp.</i> ,<br><i>Scutellospora sp.</i> & <i>Sclerocystis sp.</i>                |
|                                             | Ectomycorrhiza                 | <i>Laccaria sp.</i> , <i>Pisolithus sp.</i> , <i>Boletus sp.</i> , <i>Amanita sp.</i>                                                    |
|                                             | Ericoid mycorrhizae            | <i>Pezizella ericae</i>                                                                                                                  |
|                                             | Orchid mycorrhiza              | <i>Rhizoctonia solani</i>                                                                                                                |
| <b>Biofertilizers for Micro nutrients</b>   |                                |                                                                                                                                          |
|                                             | Silicate and Zinc solubilizers | <i>Bacillus sp.</i>                                                                                                                      |
| <b>Plant Growth Promoting Rhizobacteria</b> |                                |                                                                                                                                          |
|                                             | <i>Pseudomonas</i>             | <i>Pseudomonas fluorescens</i>                                                                                                           |

## Different types of biofertilizers

### *Rhizobium*

Rhizobium is a soil habitat bacterium, which can able to colonize the legume roots and fixes the atmospheric nitrogen symbiotically. They are the most efficient biofertilizer as per the quantity of nitrogen fixed concerned. They have seven genera and highly specific to form nodule in legumes, referred as cross inoculation group.

### *Azotobacter*

Of the several species of *Azotobacter*, *A. chroococcum* happens to be the dominant inhabitant in arable soils capable of fixing N<sub>2</sub> (2-15 mg N<sub>2</sub> fixed /g of carbon source) in culture media.

The bacterium produces abundant slime which helps in soil aggregation. The numbers of *A. chroococcum* in Indian soils rarely exceeds 10<sup>5</sup>/g soil due to lack of organic matter and the presence of antagonistic microorganisms in soil.

### *Azospirillum*

*Azospirillum lipoferum* and *A. brasilense* (*Spirillum lipoferum* in earlier literature) are primary inhabitants of soil, the rhizosphere and intercellular spaces of root cortex of graminaceous plants. They perform the associative symbiotic relation with the graminaceous plants. Five species of *Azospirillum* have been described to date *A. brasilense*, *A. lipoferum*, *A. amazonense*, *A. halopraeferens* and *A. irakense*. The organism proliferates under both anaerobic and aerobic conditions but it is preferentially micro-aerophilic in the presence or absence of combined nitrogen in the medium. Apart from nitrogen fixation, growth promoting substance production (IAA), disease resistance and drought tolerance are some of the additional benefits due to *Azospirillum* inoculation

### **Cyanobacteria**

Both free-living as well as symbiotic cyanobacteria (blue green algae) have been harnessed in rice cultivation in India. A composite culture of BGA having heterocystous *Nostoc*, *Anabaena*, *Aulosira* etc. is given as primary inoculum in trays, polythene lined pots and later mass multiplied in the field for application as soil based flakes to the rice growing field at the rate of 10 kg/ha.

The benefits due to algalization could be to the extent of 20-30 kg N/ha under ideal conditions but the labour oriented methodology for the preparation of BGA biofertilizer is in itself a limitation.

### ***Azolla***

*Azolla* is a free-floating water fern that floats in water and fixes atmospheric nitrogen in association with nitrogen fixing blue green alga *Anabaena azollae*. *Azolla* fronds consist of sporophyte with a floating rhizome and small overlapping bi-lobed leaves and roots. Rice growing areas in South East Asia and other third World countries have recently been evincing increased interest in the use of the symbiotic N<sub>2</sub> fixing water fern *Azolla* either as an alternate nitrogen sources or as a supplement to commercial nitrogen fertilizers. *Azolla* is used as biofertilizer for wetland rice and it is known to contribute 40-60 kg N/ha per rice crop.

### **Phosphate solubilizing microorganisms(PSM)**

Several soil bacteria and fungi, notably species of *Pseudomonas*, *Bacillus*, *Penicillium*, *Aspergillus* etc. secrete organic acids and lower the pH in their vicinity to bring about dissolution of bound phosphates in soil. Increased yields of wheat and potato were demonstrated due to inoculation of peat based cultures of *Bacillus polymyxa* and *Pseudomonas striata*.

### **AM fungi**

The transfer of nutrients mainly phosphorus and also zinc and sulphur from the soil *milieu* to the cells of the root cortex is mediated by intracellular obligate fungal endosymbionts of the genera *Glomus*, *Gigaspora*, *Acaulospora*, *Sclerocystis* and *Endogone* which possess vesicles for storage of nutrients and arbuscles for funneling these nutrients into the root system. By far, the commonest genus appears to be *Glomus*, which has several species distributed in soil.

### **Silicate solubilizing bacteria (SSB)**

Microorganisms are capable of degrading silicates and aluminum silicates. During the metabolism of microbes several organic acids are produced and these have a dual role in silicate weathering. They supply H<sup>+</sup> ions to the medium and promote hydrolysis and the organic acids like citric, oxalic acid, Keto acids and hydroxy carboxylic acids which form complexes with cations, promote their removal and retention in the medium in a dissolved state.

### **Plant Growth Promoting Rhizobacteria (PGPR)**

The group of bacteria that colonize roots or rhizosphere soil and beneficial to crops are referred to as plant growth promoting rhizobacteria (PGPR).

The PGPR inoculants currently commercialized that seem to promote growth through at least one mechanism; suppression of plant disease (termed Bioprotectants), improved nutrient acquisition (termed Biofertilizers), or phytohormone production (termed Biostimulants). Species of *Pseudomonas* and *Bacillus* can produce as yet not well characterized phytohormones or growth regulators that cause crops to have greater amounts of fine roots which have the effect of increasing the absorptive surface of plant roots for uptake of water and nutrients. These PGPR are referred to as Biostimulants and the phytohormones they produce include indole-acetic acid, cytokinins, gibberellins and inhibitors of ethylene production.

### **Constraints in Biofertilizer Technology :**

Though the biofertilizer technology is a low cost, ecofriendly technology, several constraints limit the application or implementation of the technology the constraints may be environmental, technological, infrastructural, financial, human resources, unawareness, quality, marketing, etc. The different constraints in one way or other affecting the technique at production, or marketing or usage.

### **Technological constraints**

- Use of improper, less efficient strains for production.
- Lack of qualified technical personnel in production units.

- Unavailability of good quality carrier material or use of different carrier materials by different producers without knowing the quality of the materials.
- Production of poor quality inoculants without understanding the basic microbiological techniques
- Short shelf life of inoculants.

#### **Infrastructural constraints**

- Non-availability of suitable facilities for production
- Lack of essential equipments, power supply, etc
- Space availability for laboratory, production, storage, etc.
- Lack of facility for cold storage of inoculant packets

#### **Financial constraints**

- Non-availability of sufficient funds and problems in getting bank loans
- Less return by sale of products in smaller production units.

#### **Environmental constraints**

- Seasonal demand for biofertilizers
- Soil characteristics like salinity, acidity, drought, water logging, etc.

#### **Human resources and quality constraints**

- Lack of technically qualified staff in the production units.
- Lack of suitable training on the production techniques.
- Ignorance on the quality of the product by the manufacturer
- Non-availability of quality specifications and quick quality control methods
- No regulation or act on the quality of the products
- Awareness on the technology
- Unawareness on the benefits of the technology
- Problem in the adoption of the technology by the farmers due to different methods of inoculation.
- No visual difference in the crop growth immediately as that of inorganic fertilizers.

#### **Awareness on the technology**

- Simultaneous cropping operations and short span of sowing/planting in a particular locality
- Unawareness on the benefits of the technology.
- Problem in the adoption of the technology by the farmers due to different methods of inoculation.
- No visual difference in the crop growth immediately as that of inorganic fertilizers.
- Unawareness on the damages caused on the ecosystem by continuous application of inorganic fertilizer.

#### **Marketing constraints**

➤ Non availability of right inoculants at the right place in right time.

Dosage of liquid Bio-fertilizers in different crops

**Recommended Liquid Bio-fertilizers and its application method, quantity to be used for different crops are as follows:**

| <b>Crop</b>                                                                                                                                        | <b>Recommended Bio-fertilizer</b>    | <b>Application method</b> | <b>Quantity to be used</b> |
|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------|----------------------------|
| Field crops<br>Pulses<br>Chickpea, pea, Groundnut,<br>soybean, beans, Lentil, lucern,<br>Berseem, Green gram, Black<br>gram, Cowpea and pigeon pea | <i>Rhizobium</i>                     | Seed treatment            | 200ml/acre                 |
| Cereals<br>Wheat, oat, barley                                                                                                                      | <i>Azotobacter/Azosp<br/>irillum</i> | Seed treatment            | 200ml/acre                 |
| Rice                                                                                                                                               | <i>Azospirillum</i>                  | Seed treatment            | 200ml/acre                 |
| Oil seeds<br>Mustard, seasmum, Linseeds,<br>Sunflower, castor                                                                                      | <i>Azotobacter</i>                   | Seed treatment            | 200ml/acre                 |
| Millets<br>Pearl millets, Finger millets, kodo<br>millet                                                                                           | <i>Azotobacter</i>                   | Seed treatment            | 200ml/acre                 |
| Maize and Sorghum                                                                                                                                  | <i>Azospirillum</i>                  | Seed treatment            | 200ml/acre                 |
| Forage crops and Grasses<br>Bermuda grass, Sudan grass,<br>Napier Grass , ParaGrass,<br>StarGrass etc.                                             | <i>Azotobacter</i>                   | Seed treatment            | 200ml/acre                 |
| Other Misc. Plantation Crops<br>Tobacco                                                                                                            | <i>Azotobacter</i>                   | Seedling<br>treatment     | 500ml/acre                 |
| Maize and Sorghum                                                                                                                                  | <i>Azospirillum</i>                  | Seed treatment            | 200ml/acre                 |
| Tea, Coffee                                                                                                                                        | <i>Azotobacter</i>                   | Soil treatment            | 400ml/acre                 |
| Rubber, Coconuts                                                                                                                                   | <i>Azotobacter</i>                   | Soil treatment            | 2-3 ml/plant               |



|                                                                                                                                                                                                |                    |                |                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------|----------------------------|
| Agro-ForestRY/Fruit Plants<br>All fruit/agro-forestry<br>(herb,shrubs, annuals and<br>perennial) plants for fuel wood<br>fodder,<br>fruits,gum,spice,leaves,flowers,nu<br>ts and seeds puppose | <i>Azotobacter</i> | Soil treatment | 2-3 ml/plant at<br>nursery |
| Leguminous plants/ trees                                                                                                                                                                       | <i>Rhizobium</i>   | Soil treatment | 1-2 ml/plant               |

### 16.3. Restrictions to nutrient use in organic farming

In organic agriculture maintenance of soil fertility may be achieved through the recycling of organic material whose nutrients are made available to crops through the action of soil micro organisms and bacteria. Many nutrient supplying inputs are restricted for us in organic farming factor such as contamination, risk of nutritional imbalances and depletion of natural resources shall be taken in to consideration.

## LECTURE- 25 & 26

# FUNDAMENTALS OF INSECT, PEST, DISEASE AND WEED MANAGEMENT UNDER ORGANIC MODE OF PRODUCTION

### 25.1 Integrated pest and disease management –

*use of bio control agents, bio pesticides, pheromones, trap crops, bird perches*

Organic farming relies heavily on the natural breakdown of organic matter, using techniques like green manure and composting, to replace nutrients taken from the soil by previous crops. This biological process, driven by microorganisms such as mycorrhiza, allows the natural production of nutrients in the soil throughout the growing season, and has been referred to as feeding the soil to feed the plant. Organic farming tends to tolerate some pest populations while taking a longer-term approach. Organic pest and disease control involves the cumulative effect of many techniques, including:

- Allowing for an acceptable level of pest and disease damage.
- Encouraging predatory beneficial insects to control pests.
- Encouraging beneficial microorganisms and insects. this by serving them nursery plants and/or an alternative habitat, usually in a form of a shelterbelt, hedgerow, or beetle bank;
- Careful crop selection, choosing disease-resistant varieties.
- Planting companion crops that discourage or divert pests.
- Using row covers to protect crops during pest migration periods.
- Using pest regulating plants and biologic pesticides, fungicides and herbicides.
- Using no-till farming, and no-till farming techniques as false seedbeds.
- Rotating crops to different locations from year to year to interrupt pest/disease reproduction cycles and
- Using insect traps to monitor and control insect populations that cause damage as well as transmit diseases.

Successful organic crop protection strategies also rely on an understanding of the effects which local climate, topography, soils and all aspects of the production system are likely to have on crop performance and the possible host/pest complexes. Organic agriculture is rapidly Pest and Disease

### 25.2 Managing Pests and Diseases

The use of synthetic pesticides are prohibited, the organic cropping system should be focused on the prevention of pest outbreaks rather than coping with them after they occur. No single method is likely to be adequate for all pests. Successful pest management depends on the incorporation of a number of control strategies. Some strategies will target insect and disease separately and others will target them together.

Pests in a crop do not automatically result in damage or yield loss. Once infestation levels reach a certain point, however, they can produce economic losses. Thresholds vary with the crop and the pest in question and must be closely monitored by the producer. Planning for effective insect and disease management must involve the entire farm operation and use all information available. Any strategy in organic farming should include methods for:

1. Insect and disease avoidance
2. Managing the growth environment
3. Direct treatment

### **25.2.1 . Avoidance Techniques**

To manage pests and diseases effectively, producers need to understand the biology and growth habits of both pest and crop. The type and concentration of pests are often responses to previous crop history, pest life cycles, soil conditions and local weather patterns.

#### **a. Crop Rotations**

Crop rotation is central to all sustainable farming systems. It is an extremely effective way to minimize most pest problems while maintaining and enhancing soil structure and fertility. Diversity is the key to a successful crop rotation program. It involves:

- Rotating early-seeded, late-seeded and fall-seeded crops
- Rotating between various crop types, such as annual, winter annual, perennial, grass and broadleaf crops; each of these plant groups has specific rooting habits, competitive abilities, nutrient and moisture requirements. (True diversity does not include different species within the same family - for example, wheat, oats and barley are all species of annual cereals.)
- Incorporating green manure crops, into the soil to suppress pests, disrupt their life cycles and to provide the additional benefits of fixing nitrogen and improving soil properties

- Managing the frequency with which a crop is grown within a rotation
- Maintaining the rotation's diversified habitat, which provides parasites and predators of pests with alternative sources of food, shelter and breeding sites
- Planting similar crop species as far apart as possible. Insects such as wheat midge and Colorado potato beetle, for example, are drawn to particular host crops and may overwinter in or near the previous host crops. With large distances to move to get to the successive crop, the insects' arrival may be delayed. The number that find the crop may be reduced as well.

Diverse rotations are particularly effective in regulating flea beetles, cabbage butterfly, wheat midge, wheat stem maggot and wheat stem sawfly. Organic Ecosystem Rotations are also effective in controlling soil- and stubble-borne diseases. Rotations will not have much effect on pathogens that live indefinitely in the soil, but will shorten the life span of pathogens that can survive only brief periods apart from their hosts. Other situations that limit the benefit of crop rotations include: the transmission of pathogens via seed, the presence of susceptible weeds and volunteer crops that harbor pathogens, and the invasion of pathogens by wind and other means. Rotations should be used with other cultural practices to achieve the greatest benefit

#### **b. Field Sanitation/Crop Residue Management**

Reducing or removing crop residues and alternate host sites can be used to control some insects and many diseases. Incorporating the residue into the soil hastens the destruction of disease pathogens by beneficial fungi and bacteria. Burying diseased plant material in this manner also reduces the movement of spores by wind.

Insects most affected by tillage will be those that over winter in crop residue (for example, European corn borer and wheat stem sawfly) and those that lay their eggs in the residue. Conversely, fields where residue has not been disturbed may have higher levels of some beneficial predaceous insects, which may reduce levels of insect pests such as root maggots in canola. Alternate host sites, such as field margins, fence lines, pastures, shelterbelts and riparian areas, will usually contain weeds and natural vegetation that may serve as reservoirs for disease, vectors of disease and insect pests. Left uncontrolled, these insect and disease pests can be transmitted to healthy crop plants.

#### **c. Seed Quality**

The use of high-quality seed is especially important in preventing disease. The seed supply should be free of smut, ergot bodies or other sclerotia, and free of kernels showing symptoms of Fusarium head blight infection.

#### **d. Weed Management**

Although weeds need to be controlled to reduce their impact on crop yield and quality, a field completely free of weeds is not necessarily the best objective. In many cases, weeds provide food and shelter for beneficial insects. Parasitic wasps, for example, are attracted to certain weeds with small flowers. Field experience has shown that the number of predators attacking insects increases and the number of aphids and leafhoppers decreases on certain crops as the diversity of weeds (that act as host plants) increases.

### **25.2.2. Managing the Growth Environment - Giving the Crop a Head Start**

Any crop management technique that contributes to a vigorous, competitive crop is a tool of insect and disease management.

#### **a. Healthy Soil**

Maintaining favorable soil conditions is the first line of defense against pests. A biologically active soil with good drainage supports vigorous crop growth, allowing a higher level of crop competition with weeds. Adequate, balanced soil nutrition is essential for crop quality, yield and moisture-use efficiency. High levels of nitrogen can occur after a high-nitrogen plow down, such as sweet clover. This results in lush leaf tissue and a dense plant canopy that provides an ideal environment for plant pathogens. Inadequate soil phosphorous can pre-dispose to certain root diseases. Low levels of nitrogen can reduce the incidence of insect outbreaks. A shortage of micronutrients such as zinc or copper can result in disease-like symptoms on crops, while too much of any one micronutrient may be toxic. The addition of composted livestock manure improves soil quality, including increasing the population of soil micro-organisms that compete with soil-borne plant pathogens.

#### **b. Crop and Variety Selection**

The selection of insect- and disease-resistant cultivars can be a useful tool, but under no circumstances can genetically modified varieties be used in organic systems.

Plants also vary in their degree of attractiveness to insects, diseases and vectors transmitting disease. Factors such as leaf and stem toughness, pubescence, nutrient content, plant architecture, growth habit and differences in maturity between crops and varieties can influence pest growth, reproduction and host preference. For example, earlier-maturing crop varieties may be less attractive to migrating populations of grasshoppers late in the season compared to later-maturing varieties.

### **c. Intercropping**

The practice of intercropping (where two crops are grown at the same time) can reduce pest problems by making it more difficult for the pests to find a host crop. This technique also provides habitat for beneficial organisms. Strip-cropping row crops with perennial legumes often leads to better pest control. In particular, alfalfa attracts many beneficial organisms that can destroy insect pests in neighboring crops.

### **d. Seeding Date**

Early seeding reduces crop damage caused by grasshoppers, aphids in cereal crops.

### **e. Seeding Rate**

Using a higher seeding rate to affect insect or disease infestations may have different results. More plants in a field may reduce the impact of a given aphid population on individual plants, but they may create a more favorable habitat for insects that prefer a dense canopy, such as true armyworm. A dense leaf canopy can also create a moist soil surface and elevated humidity within the crop, conditions favorable to certain leaf disease pathogens.

Reducing the seeding rate may decrease the severity of take-all in spring wheat, but the reduced canopy may also allow weeds to invade. In other crops, reduced seeding may also produce more insect damage, as in the case of aphids, flea beetles and leafhoppers, which are attracted to the contrast between a green host and a dark soil background.

### **f. Depth and Timing of Seeding**

Optimum seeding depth is also important. Deep seeding in cold soils may result in seedling blights and damping-off, especially in pulses and small seeded crops. Seeding depth should generally be no deeper than required for quick germination and even emergence. Variables include seed size, soil type and moisture conditions. For most crops, seeding should ideally be done when the soil is warm enough for rapid germination. Seeds that remain ungerminated in cool soil are more susceptible to damage by insects such as wire worms.

### **g. Trap Strips**

Seeding trap strips around the edge of a cropped field or along a fence row helps lure insect pests to a specific area where they can be managed more easily. Similarly, a trap strip of potatoes planted much earlier than the main crop would attract Colorado potato beetles to the area. The strip could be worked under along with the adult beetles, eggs and larvae before the second generation of beetles spreads to the main crop.

Generally, the insect pests in the trap strips are controlled by mowing or cultivating the strip, or by applying an acceptable organic product, such as *Bacillus thuringiensis*. Trap strips can also act as a barrier to protect the crop field.

### **h. Tillage**

Tillage can be properly timed before seeding, after harvesting and during summer fallow to reduce populations of insect pests such as cutworms and grass hoppers that spend part of their life cycles in the soil or stubble.

### **i. Roguing**

Roguing refers to the labour-intensive practice of walking the fields to remove diseased or insect-infested plants.

## **25.2.3. Direct Treatment**

At times, the organic producer will find that, despite all the best efforts, an insect or disease pest will grow to levels that cause substantial crop damage. At this point, direct treatment may be necessary.

### **a. Monitoring**

Insect monitoring traps are useful in determining which insect pests are present in a field and whether they are at economically important levels. Certain types of insect hormones called pheromones may be used as attractants to monitor population levels of insects such as bertha armyworm, diamondback moth, cabbage looper and European corn borer, or to simply attract insects into a trap.

### **b. Biological Control**

In a healthy, balanced ecosystem, biological control by natural predators is constantly occurring. The more diverse a cropping system becomes, the greater the spectrum of insect species and micro-organisms within

it. This leads to the development of more natural predators within the ecosystem. Ladybugs, ambush bugs, hoverfly larvae, lacewings, spiders, birds, frogs, toads and a host of other insects are predators of aphids, bertha armyworm larvae, sunflower beetles, beet webworms, and both grasshopper eggs and adults. The destructive wheat midge may also be partially controlled by a parasitic wasp, but crop damage may still occur.

Various types of fungi are insect parasites and can either kill their insect hosts or reduce their ability to reproduce. Very few biological controls are available to reduce the effects of plant diseases, as most commercial products do not perform well if the disease is already established in the crop. Myco parasitism is a form of bio-control where one fungus parasitizes another. Although this process occurs with many fungi under laboratory conditions, it hasn't been successful under field conditions.

### **c. Natural Insecticides**

Organic certification standards prohibit the use of synthetic pesticides. Permitted disease-management products include copper (fixed copper and copper sulphate), lime-sulphur mixes, elemental sulphur, vinegar, soap and silica. Bordeaux mixture is considered a restricted substance, and farmers should contact their certifying body before using it. Although these products are allowed, it may not be cost-effective or feasible to apply them to field crops.

Insecticides permitted in organic agriculture include some microbial insecticides containing the bacteria *Bacillus thuringiensis*. Three main strains of these bacteria are used in insect control. One strain, marketed as Dipel or Thuricide, kills only the larvae of moths or butterflies. Another strain, marketed as Novodor, is for beetle larvae only and can be used to control Colorado potato beetles. The third strain is specifically for mosquito and fly larvae.

Botanical insecticides, such as rotenone, are also permitted in organic agriculture, but they are often too expensive to use on large acreages.

#### **25.2.4 Other Control Methods**

For pest control, beneficial organisms, dormant oil, diatomaceous earth, plant-derived pesticides, soap, natural and synthetic insect pheromones which disrupt the insect's development, and commercial insect vacuums can be used.

### **a. Grain Storage**



When stored grain is dry and its temperature is low, problems seldom arise. But if the grain is warm and moist, insects and fungi can multiply rapidly. A grain temperature of 5°C to 10°C is adequate for long-term storage. Bin aeration helps dry and cool the grain. If bins are not equipped with aeration systems, grain can be moved to cool it. Cold temperatures can be used to control insects that exist in stored grain.

Before storing new grain, the bin should be thoroughly cleaned with a grain vacuum. The empty bin can be treated with diatomaceous earth to control stored-grain insects.

#### **b. Natural products for Pest Control**

- Using various naturally occurring substances and products Eg. Neem, pongamia, NPV, Trichograma, Trichoderma etc

#### **c. Community Management**

- Pest incidence depends not only on the crop a farmer grows and practices he/she follows but also on the neighboring cropping pattern and the practices adopted.

#### **List of inputs permitted for crop protection**

##### **Input Permitted /Restricted**

1. Mechanical traps, Neem oil and other preparations, Propalis, Pheromones in traps, plant based repellants, Silicates, Soft soap -*Permitted*
2. Copper salts, Chloride of lime/soda, light mineral oils, permanganate of potash, Sulphur, Viral, fungal and bacterial preparations, release of parasite and predators of insect pests-*Restricted*

##### **All-round Herbal Pesticide**

Herbal extracts should be used only as a final remedy only after utilizing and practicing all the above said methods. One should try to use only the locally available weeds or those that are grown as life fence for making herbal extracts.

Basic important procedures to be followed while preparing the herbal extracts are:

- Macerate and grind the plant material to a pulp state. This is mainly to expose the cells and facilitate the extraction of the active principle with the help of water.
- Soak the pulped material in at least 70-80% of the final volume of spray solution.
- Since the water has a limited dissolving capacity, with low volume the extraction will not be full.

- Soak the pulped material only for 3-5 days. If it is allowed to ferment for more number of days the active principles from the herbs that are needed to kill the insects will disintegrate into simpler harmless component.
- After 3 - 5 days of fermentation, the whole solution should be filtered and the final spray volume should be made by adding the balance water.
- The filtered final solution has to be sprayed in such a way that the whole plant is fully drenched at least one or two times in a year.
- To avoid soaking for 3-4 days, soak it at least overnight and then heat it to bearable warmth (60-70°C) for an hour by stirring. After this dilute it to the required final volume of spray solution, filter, allow cooling and spraying.
- Use at least 2-3 different materials at a time to prepare the herbal extract.
- Change the combination of the materials every time.
- Use 2-3% of herbal extract (combination of 2-3 different materials) while the pest attack is at early stage. Increase the dosage to 5-6% if the attack is very severe.
- The first two sprays in a season should be a blanket spray, on observing the attack.

## LECTURE -27

# FUNDAMENTALS OF WEED MANAGEMENT UNDER ORGANIC MODE OF PRODUCTION

### Weed Management

#### 27.1 Organic weed management

Weeds can be considered a significant problem because they tend to decrease crop yields by increasing competition for water, sunlight and nutrients while serving as host plants for pests and diseases. Using herbicides increased crop yields and reduced the labor required to remove weeds. In some cases herbicides use can cause some weed species to dominate fields because the weeds develop resistance to herbicides. In addition, some herbicides are capable of destroying weeds that are harmless to crops, resulting in a potential decrease in biodiversity on farms.

It is important to understand that under an organic system of weed control, weeds will never be eliminated but only managed.

#### 27.2 Critical period of weed control

This period has been defined as an interval in the life cycle of the crop when a must be kept weed – free to prevent yield loss. If weeds have been controlled throughout the critical period, the weeds that emerge later will not affect yield and can be controlled prior to harvest with a harvest and to burn down the weeds and desiccate the crop. Horticulture crops are very sensitive to weed competition, and need to to keep weed-free, from planting, emergence or bud break, until the end of their critical weed –free period. If the crop is kept weed-free for the critical period, generally no yield reduction would result.

#### 27.3 Critical Weed-free Period for Horticultural Crops

| Crop             | Critical Weed-free Period   |
|------------------|-----------------------------|
| Cabbage, early   | 3 weeks after planting      |
| Carrots          | 3-6 weeks after emergence   |
| Cucumbers        | 4 weeks after seeding       |
| Lettuce          | 3 weeks after planting      |
| Onions           | The whole season            |
| Potatoes         | 4 weeks after planting      |
| Tomatoes, fresh  | 36 days after transplanting |
| Tomatoes, seeded | 9 weeks after seeding       |

### **27.3.1. Cultural Method**

#### **a. Crop rotation**

Crop rotation is an important strategy for developing a sound long term weed control program. Weeds tend to thrive with crops of similar growth requirements as their own and cultural practices designed to contribute to the crop may also benefit the growth and development of weeds. Monoculture, that is growing the same crop in the same field year after year, results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, etc).

Within a rotation, crop choice will determine both the current and the potential future weed problems that a grower will face. Inclusion of a fallow period in the rotation is known to reduce perennial weeds. It is best to alternate legumes with grasses, spring planted crops with fall planted crops, row crops with close planted crops and heavy feeders with light feeders.

#### **b. Cover crops**

Rapid development and dense ground covering by the crop will suppress weeds. The inclusion of cover crops such as rye, red clover, buckwheat and radish or winter crops like winter wheat or forages in the cropping system can suppress weed growth. Highly competitive crops may be grown as short duration 'smother' crops within the rotation.

The cover crop residues on the soil surface will suppress weeds by shading and cooling the soil. When choosing a cover crop, consideration should always be given to how the cover crop will affect the succeeding crop. In addition, decomposing cover crop residues may release allelo chemicals that inhibit the germination and development of weed seeds.

#### **c. Intercropping**

Intercropping involves growing a smother crop between rows of the main crop. Intercrops are able to suppress weeds. However, the use of intercropping as a strategy for weed control should be approached carefully. The intercrops can greatly reduce the yields of the main crop if competition for water or nutrients occurs.

#### **d. Field Scouting**

It involves the systematic collection of weed and crop data from the field (weed distribution, growth stage, population, crop stage etc). The information is used, in the short term, to make immediate weed management decisions to reduce or avoid economic crop loss. In the long term, field scouting is important

in evaluating the success or failure of weed management programs and for making sound decisions in the future.

#### **e. Mulching**

Mulching or covering the soil surface can prevent weed seed germination by blocking light transmission preventing seed germination. Allelopathic chemicals in the mulch also can physically suppress seedling emergence. There are many forms of mulches available.

##### **i. Living mulch**

Living mulch is usually a plant species that grows densely and low to the ground such as clover. Living mulches can be planted before or after a crop is established. It is important to kill and till in, or manage living mulch so that it does not compete with the actual crop. Often, the primary purpose of living mulch is to improve soil structure, aid fertility or reduce pest problems and weed suppression may be merely an added benefit.

##### **ii. Organic mulches**

Such materials as straw and composted material can provide effective weed control. Producing the material on the farm is recommended since the cost of purchased mulches can be prohibitive, depending on the amount needed to suppress weed emergence. Organic mulches have the advantage of being biodegradable.

#### **f. Planting patterns**

Crop population, spatial arrangement, and the choice of cultivar (variety) can affect weed growth. For example, studies have shown that narrow row widths and a higher seeding density will reduce the biomass of later-emerging weeds by reducing the amount of light available for weeds located below the crop canopy. Similarly, fast growing cultivars can have a competitive edge over the weeds.

#### **g. Variety selection**

Careful selection of crop varieties is essential to limit weeds and pathogen problems and to satisfy market needs. Any crop variety that is able to quickly shade the soil between the rows and is able to grow more rapidly than the weeds will have an advantage.

#### **h. Tillage system**

Tillage systems alter the soil seed bank dynamics and depth of burial of weed seeds. Studies have found that almost 75% of the seed bank will be concentrated in the upper 5 cm of soil in no-till fields. In the moldboard plough system however, the seed bank is more uniformly distributed over depth. Other conservation tillage systems are intermediate to these two systems.

Weed seedling emergence is often more uniform with shallow buried weed seeds and may result in better weed control. Weed seeds closer to the soil are more likely to be eaten or damaged by insects, animals, other predators and disease causing organisms.

#### **i. Sanitation**

It is possible to prevent many new weeds from being introduced onto the farm and to prevent existing weeds from producing large quantities of seed.

The use of clean seed, mowing weeds around the edges of fields or after harvest to prevent weeds from going to seed, and thoroughly composting manure before application can greatly reduce the introduction of weed seeds and difficult weed species. Planting clean, high-quality seed is essential to crop success. Other sanitation factors to consider would include thorough cleaning of any machinery which might have been used in weedy fields, and the establishment of hedgerows to limit windblown seeds.

#### **j. Nitrogen fertility**

Use of legume residues are opposed to chemical nitrogen fertilizer to supplement nitrogen needs of the crop can enhance weed suppression. Legume residues release nitrogen slowly with less stimulation of unwanted weed growth.

#### **k. Water management**

Effective water management is key to controlling weeds in a vegetable operation. There are a number of ways that careful irrigation management can help you reduce weed pressure on crops:

##### **i. Pre-germination of weeds (Stale seed bed)**

In pre-germination irrigation or rainfall germinates weed seeds just before the cash crop is planted. The newly germinated weeds can be killed by light cultivation. Pre-germination should occur as close as possible to the date of planting to ensure that changes in weather conditions do not have an opportunity to change the spectrum of weeds (cool vs. warm season) in the field.

##### **ii. Planting to moisture**

After weeds are killed by cultivation, the top 2 to 3 inches of soil are allowed to dry and form dust mulch. At planting, the dust mulch is pushed away and large-seeded vegetables such as beans can be planted into the zone of soil moisture. These seeds can germinate, grow, and provide partial shading of the soil surface without supplemental irrigations that would otherwise provide for an early flush of weeds.

##### **iii. Buried drip irrigation**

Drip tape buried below the surface of the planting bed can provide moisture to the crop and minimize the amount of moisture that is available to weeds closer to the surface. If properly managed, this technique can provide significant weed control during dry period.

### **25.3.2. Mechanical Weed Control**

Mechanical removal of weeds is both time consuming and labor-intensive but is the most effective method for managing weeds. Cultivation involves killing emerging weeds or burying freshly shed weed seeds below the depth from which they germinate. The soil seed bank is the reserve of weed seeds present in the soil. Observing the composition of the seed bank can help a farmer make practical weed management decisions. Burial to 1 cm depth and cutting at the soil surface are the most effective ways to control weed seedlings mechanically. Mechanical weeders include cultivating tools such as hoes, harrows, tines and brush weeders, cutting tools like mowers. The choice of implement and the timing and frequency of its use depends on the morphology of the crop and the weeds. Hand hoes, push hoes and hand-weeding are still used when rouging of an individual plant or patch of weed is the most effective way of preventing the weed from spreading. Hand-weeding may also be used after mechanical inter-row weeding to deal with weeds left in the crop row. Shallow between-row cultivators such as basket-weeders, beet-hoes, or small sharp sweeps are used to cut off and uproot small weeds after the crop attains certain growth.

### **25.3.3. Thermal Weed Control**

#### **a. Flamers**

Flamers are useful for weed control. Thermal weed control involves the use of flaming equipment to create direct contact between the flame and the plant. This technique works by rupturing plant cells when the sap rapidly expands in the cells. Sometimes thermal control involves the outright burning down of the weeds. Flaming can be used either before crop emergence to give the crop a competitive advantage or after the crop has emerged. However, flaming at this point in the crop production cycle may damage the crop. Although the initial equipment cost may be high, flaming for weed control may prove cheaper than hand weeding.

Flaming does not burn weeds to ashes; rather the flame rapidly raises the temperature of the weeds to more than 130 °F. The sudden increase in temperature causes the plant's cell sap to expand, rupturing the cell walls. For greatest flaming efficiency, weeds must have fewer than two to three leaves. Grasses are difficult to impossible to kill by flaming because the growing point is protected underground.

#### **b. Soil solarization**

Materials such as black polyethylene have been used for weed control in a range of crops in organic production systems. Plastic mulches have been developed that filter out photosynthetically active radiation, but let through infrared light to warm the soil. These infrared transmitting mulches have been shown to be effective at controlling weeds.

During summer and fall, organic farmers sterilize their soil through solarization. In this process, a clear plastic film is placed over an area after it has been tilled and tightly sealed at the edges. Solarization works when the heat created under the plastic film becomes intense enough to kill weed seeds.

### **c. Infrared weeders**

Infrared weeders are a further development of flame weeding in which the burners heat ceramic or metal surfaces to generate the infrared radiation directed at the target weeds. Some weeders use a combination of infrared and direct flaming to kill the weeds. In general, flame weeders are considered to be more effective because they provide higher temperatures, but burner height and plant stage are important too. Infrared weeders cover a more closely defined area than those of the standard flame weeder, but may need time to heat up.

### **d. Freezing**

Freezing would be advantageous only where there is an obvious fire risk from flaming. Liquid nitrogen and solid carbon dioxide (dry ice) can be used for freezing weeds.

#### 25.3.4. Biological Weed Control

Biological control would appear to be the natural solution for weed control in organic agriculture.

### **a. Allelopathy**

Allelopathy is the direct or indirect chemical effect of one plant on the germination, growth or development of neighboring plants. It is now commonly regarded as a component of biological control. Species of both crops and weeds exhibit this ability. Allelopathic crops include barley, rye, annual ryegrass, buckwheat, oats, sorghum, sudan sorghum hybrids, alfalfa, wheat, red clover, and sunflower. Vegetables, such as horseradish, carrot and radish, release particularly powerful allelopathic chemicals from their roots.

### **b. Beneficial organisms**

Natural enemies that have so far been successful include a weevil for the aquatic weed salvinia, a rust for skeleton weed and probably the most famous, a caterpillar (*Cactoblastis* sp.) to control prickly pear. There is also considerable research effort aimed at genetically engineering fungi (myco-herbicides) and bacteria so that they are more effective at controlling specific weeds. Myco-herbicides are a preparation containing pathogenic spores applied as a spray with standard herbicide application equipment.

Weeds are subject to disease and insect attacks just as crops are. Geese have been used for weed control in trees, vine, and certain row crops. Most types of geese will graze weeds, but Chinese weeder geese are considered the best for row crops.



**c. Use of fish foe weed control**

| Name of the weeds            | Fish                     |
|------------------------------|--------------------------|
| Lemma, Hydrilla, Potamogeton | Grass carp or white amur |
| Algae                        | Silver carp, common carp |

**Use of competitive plants for weed control**

| Name of the weeds               | Competitive plants       |
|---------------------------------|--------------------------|
| <i>Parthenium hysterophorus</i> | <i>Cassia sericea</i>    |
| <i>Typha</i> sp.                | <i>Brachiaria mutica</i> |

**Use of biocontrol agents for weed control**

| Name of the weed                   | Bioagent                                                                                                     |
|------------------------------------|--------------------------------------------------------------------------------------------------------------|
| <i>Cyperus rotundus</i>            | <i>Bactra verutana</i>                                                                                       |
| <i>Ludwigia parviflora</i>         | <i>Haltica cynea</i> (Steel blue beetle)                                                                     |
| <i>Parthenism hysterophorus</i>    | <i>Zygogramma bicolarata</i>                                                                                 |
| <i>Lantana camara</i>              | <i>Crociosema lantana</i> , <i>Teleonnemia scrupulosa</i>                                                    |
| <i>Opuntia dilleni</i>             | <i>Dactylopius tomentosus</i> , <i>D. Indicus</i> (cochineal scale ect)                                      |
| <i>Eichhornea crassipes</i>        | <i>Neochetina eichhornea</i> , <i>N. Bruchi</i> (Hyacinth evil) <i>Sameodes alliguttalis</i> (hyacinth moth) |
| <i>Iminia molesta</i>              | <i>Cryptobagus singularis</i> (weevil) <i>Paulinia iminate</i> (grass hopper), <i>Samea mutipicalis</i>      |
| <i>Alternanthera philoxaroides</i> | <i>Agasides hygrophilla</i> (flea beetle) <i>Amynothrips dersoni</i>                                         |
| <i>Tribulus terrestris</i>         | <i>Microlarinus lypriformis</i> , <i>M. lareynii</i>                                                         |
| <i>Solanum elaeagnifolium</i>      | <i>Frumenta nephalomicta</i>                                                                                 |

**Comercial mycoherbicides**

| Trade name | Pathogen                     | Target weed                                 |
|------------|------------------------------|---------------------------------------------|
| Devine     | <i>Phyophthora palmivora</i> | <i>Morreria odorata</i> (Strangler vine) in |

|            |                                                                 |                                                                         |
|------------|-----------------------------------------------------------------|-------------------------------------------------------------------------|
|            |                                                                 | citrus                                                                  |
| Collego    | <i>Colletotrichum gleosporoides</i><br><i>f.sp. aeshynomene</i> | <i>Aeshynomene virginica</i> (northern joint vetch) in rice and soybean |
| Biopolaris | <i>Biopolaris sorghicola</i>                                    | <i>Sorghum halepense</i> (Johnson grass)                                |
| Biolophos  | <i>Streptomyces hygroscopius</i>                                | General vegetation(non-specific)                                        |

# **LECTURE 28**

## **OPERATIONAL STRUCTURE OF NPOP**

### **28.1 Introduction**

To provide a focused and well-directed development of organic agriculture and quality products, Ministry of Commerce and Industry, Government of India, launched a National Program on Organic Production (NPOP) in the year 2000, which was formally notified in October 2001 under the Foreign Trade & Development Act (FTDR Act). The standards and procedures have been formulated in harmony with international standards such as those of Codex and IFOAM. NPOP is implemented under AGMARK by Ministry of Agriculture for the domestic market. The National Programme for Organic Production proposes to provide an institutional mechanism for the implementation of National Standards for Organic Production, through a National Accreditation Policy and Programme.

### **28.2 Aim**

The aims of the National Programme for organic production include the following:

- To provide the means of evaluation of certification programmes for organic agriculture and products as per the approved criteria.
- To accredit certification programmes
- To facilitate certification of organic products in conformity to the National Standards for Organic Products.
- To encourage the development of organic farming and organic processing.

### **28.3 Scope**

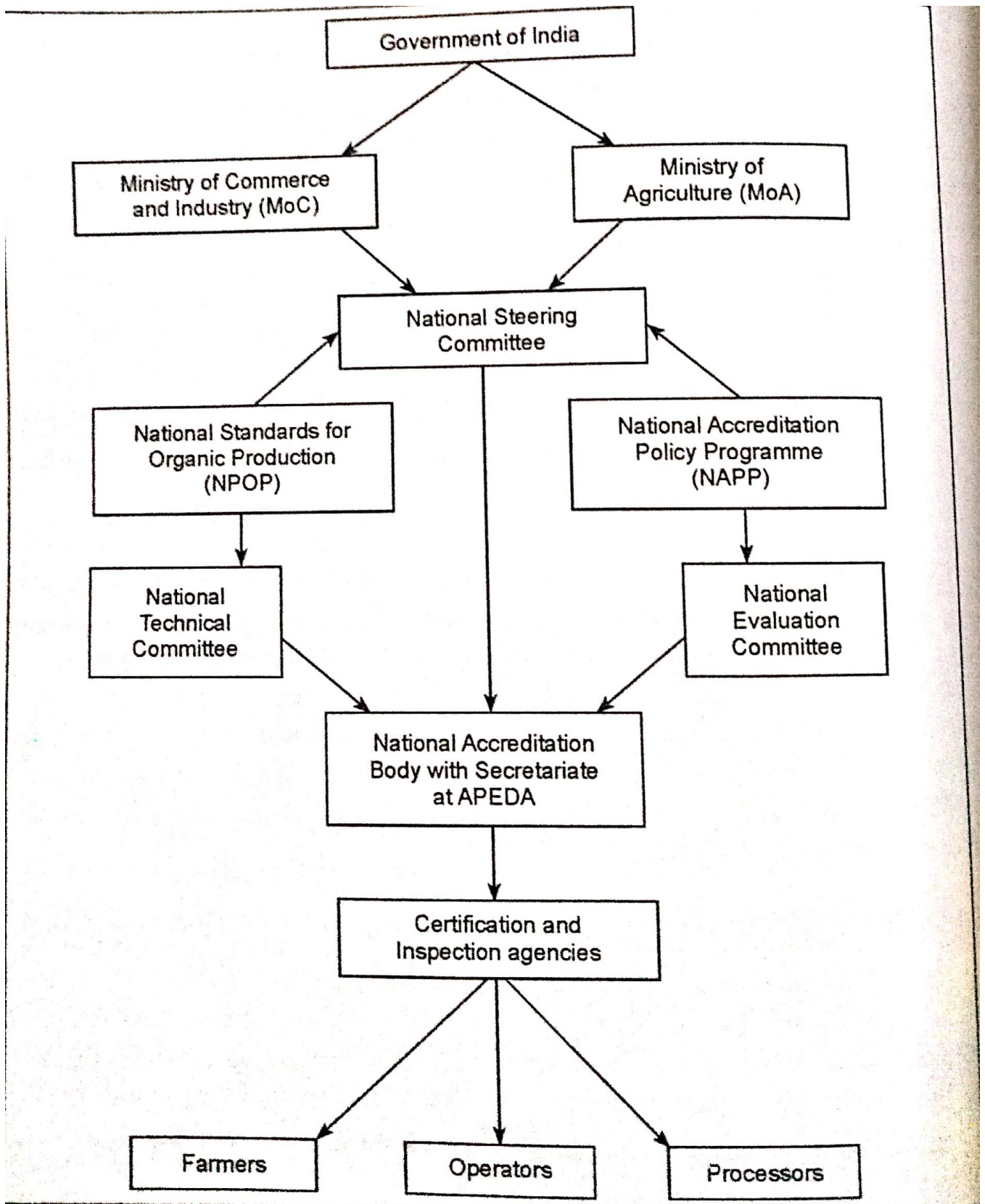
The National Programme for Organic Production shall, among others, include:

1. Policies for development and certification of organic products
2. National standards for organic products and processes
3. Accreditation of programmes to be operated by Inspection and Certification Agencies
4. Certification of organic products

### **28.4 Major objective of NPOP:**

1. Traceability
2. To streamline and fasten the process of Organic certification

3. To gather information of each consignment that goes out of India
4. To trace the consignments upto farm
5. To plug all the loopholes and create a fool proof system
6. To stop fraudulent activities for better brand building of Indian Organic products in the world
7. To bring all the players at the same level
8. To gain trust about credibility of organic products
9. To enhance the assurance to the consumers in Indian Organic products in the global market



**FIG 7.1 Operational structure of national programme for organic production (NPOP)**

The programme will be developed and implemented by the Government of India through its Ministry of Commerce and Industry as the apex body. The Ministry will constitute a National Steering Committee for National Programme for Organic Production, whose members will be drawn from Ministry of Commerce and Industry, Ministry of Agriculture, Agricultural and Processed Food Products Export Development Authority (APEDA), Coffee Board, Spices Board and Tea Board and other government and private organisations associated with the organic movement. To advise the National Steering Committee on relevant issues into National Standards and Accreditation, sub-committees will be appointed. The Steering Committee for National Programme for Organic Production will formulate Accreditation Policy and Programme and draw up National Standards for Organic Products, which will include standards for organic production and processes as well as the regulations for use of the National Organic Certification Mark. National Accreditation Policy Programme will be administered by the National Accreditation Body, which will define the overall policy objectives for the Accreditation programmes and operations. The National Steering Committee may amend the Accreditation procedures whenever it deems fit. The National Accreditation Policy and Programme is subject to periodic internal review, which will be conducted by the Technical Committee, which will advise the National Steering Committee about the need and content of such amendments in the National Programme for Organic Production.

### **28.5 National Accreditation Body**

National Steering Committee would also function as the National Accreditation Body. Members of the National Accreditation Body shall comprise of representatives from Ministry of Agriculture, Ministry of Commerce and Industry, APEDA, Coffee Board, Spices Board Tea Board. The Chairman of the Body shall be the Chairman of the National Steering Committee. The work of the National Accreditation Body will include:

1. Drawing up procedures for evaluation and accreditation of certification programmes.
2. Formulation procedures for evaluation of the agencies implementing the programmes.
3. Accreditation of inspection and certification agencies.

Every certifier will implement a certification programme and a programme cannot be implemented without accrediting the certifier.

## **28.6. Evaluation Committee**

Eligible Inspection and Certification Agencies implementing certification programmes will be evaluated by an evaluation committee. The evaluation committee will be accredited by the National Accreditation Body. The members of the Evaluation Committee will comprise of members drawn from APEDA, Coffee Board, Spices Board, Tea Board, Ministry of Agriculture and Export Inspection Council of India (EIC/Export Inspection Agencies (EIAS)). The APEDA, on behalf of National Accreditation Body from the certification agencies, will receive and screen applications from the certification agencies, will coordinate and arrange evaluation visits etc to ascertain the credentials of certification program of the applicants.

## **28.7 National Standards for Organic Farming**

Under NPOP programme, the Govt. of India has developed National Standard for organic export. The Ministry of Agriculture, in principle, has accepted this standard for domestic purpose also. The scopes of these standards are:

1. Lay down policies for development and certification of organic products.
2. Facilitate certification of organic products conforming to the National Programme containing the standards for organic production.
3. Institute a logo and prescribe its award by accrediting bodies on products qualifying for bearing India organic label.

A National Steering Committee (NSC) comprising Ministry of Commerce, Ministry of Agriculture, APEDA, Spices Board, Coffee Board, Tea Board and various other Government and private organisations associated with the organic movement is monitoring the overall organic activities under the National Programme for organic production (NPOP)

## **28.9 Crop production**

### **28.9.1 Choice of crops and varieties**

#### **Standards**

- When organic seed and plant materials are available , they shall be used.
- When certified organic seed and plant material are not available, chemically untreated conventional materials shall be used.

### **28.9.2 Duration of conversion period**

#### **Standards**

- Plant products produced can be certified organic when the national standard requirements have been met during a conversion period of at least two years sowing or in the case of perennial crops other than grassland, at least three years (thirty-six months) before the first harvest of products. The conversion period can be extended by the certification programme depending on the past use of the land and environmental conditions.
- The certification programme may allow plant products to be sold as produce of organic agriculture in process of conversion" or a similar description during the conversion period of the farm.
- For the calculation of inputs for feeding, the feed produced on the farm unit during the first year of organic management, may be classified as organic.

### **28.9.3 Diversity in Crop Production**

#### **Standards**

Where appropriate, the certification programme shall require that sufficient diversity is obtained in time or place in a manner that takes into account pressure from insects, weeds, diseases and other pests, while maintaining or increasing soil organic matter, fertility, microbial activity and general soil health .For non perennial crops , this is normally but not exclusively, achieved by means of crop rotation

### **28.9.4 Fertilisation policy**

#### **Standards**

- Biodegradable material of microbial, plant or animal origin shall form the basis of fertilisation programme
- The certification programme shall set limitations to the total amount of bio degradable material of microbial, plant or animal origin brought onto the farm unit.
- Manures containing human excreta (faeces and urine ) shall not be used.
- Mineral fertilizer shall be applied in the natural composition and shall not be rendered more soluble by chemical treatment.



- The certification programme shall lay down restrictions for the use of inputs such as mineral potassium fertilizers, manures with a relatively high heavy metal content and other unwanted substances.

### **28.9.5 PEST DISEASE WEED MANAGEMNT INCLUDING GROWTH REGULATORS**

#### **Standards**

- Thermic weed control and physical methods for pest, disease and weed management are permitted
- Thermic sterilization of soil to combat pests and diseases is restricted to circumstances where a proper rotation or renewal of soil cannot take place. Permission may be given by the certification programme only on a case by case basis
- All equipments from conventional farming systems shall be properly cleaned and free from residues before being used on organically managed areas.
- Use of synthetic herbicides, fungicides, insecticides and other pesticides is prohibited .
- Use of synthetic growth regulators and synthetic dyes are prohibited.
- Accredited certification programmes shall ensure that measures are in place to prevent transmission of pests, parasites and infectious agents.

### **28.9.6 Contamination control**

#### **Standards**

- In case of reasonable suspicion of contamination, the certification programme shall make sure that an analysis of the relevant products to detect the possible sources of pollution (soil and water), shall take place to determine the level of contamination
- For protected structure coverings, plastic mulches, fleece, insect netting and silage rapping, only products based on polyethylene and polypropylene or other polycarbonates are allowed. These shall be removed from the soil after use and shall not be burnt on the farmland.

### **28.9.7 Soil and water conservation**

#### **Standards**

- Clearing of land through the means of burning organic matter (slash-and burn, straw burning) shall be restricted to the minimum.
- Clearing of primary forest is prohibited.

- Relevant measures shall be taken to prevent erosion.
- Certification programme shall require appropriate stocking rates which do not lead to land degradation and pollution of ground and surface water
- Relevant measures shall be taken to prevent salinization of soil and water

#### **28.9.8 Collection on non cultivated material of plant origin and honey**

##### Standards

- Wild harvested products shall only be confused organic if derived from a stable and sustainable growing environment .
- Products can only be certified organic if derived from a clearly defined collecting area, which is not exposed to prohibited substances and which is subject to inspection
- . Collection area shall be at an appropriate distance from conventional farming, pollution and contamination.
- Operator managing the harvesting or gathering of the products shall be clearly identified and be familiar with the collecting area in question.

# LECTURE 29 & 30

## CERTIFICATION PROCESS AND STANDARDS OF ORGANIC FARMING

### 29.1. Certification

Organic certification is a certification process for producers of organic food and other organic agricultural products. In general, any business directly involved in food production can be certified, including seed suppliers, farmers, food processors, retailers and restaurants. Requirements vary from country to country, and generally involve a set of production standards for growing, storage, processing, packaging and shipping that include:

- Avoidance of most synthetic chemical inputs (e.g. fertilizer, pesticides, antibiotics, food additives, etc), genetically modified organisms, irradiation, and the use of sewage sludge;
- Use of farmland that has been free from synthetic chemicals for a number of years
- Keeping detailed written production and sales records (audit trail);
- Maintaining strict physical separation of organic products from non-certified products;
- Undergoing periodic on-site inspections.

In some countries, certification is overseen by the government, and commercial use of the term *organic* is legally restricted. Certified organic producers are also subject to the same agricultural food safety and other government regulations that apply to non-certified producers.

### 29.2 Purpose of certification

Organic certification addresses a growing worldwide demand for organic food. It is intended to assure quality and prevent fraud. For organic producers, certification identifies suppliers of products approved for use in certified operations. For consumers, "certified organic" serves as a product assurance, similar to "low fat", "100% whole wheat", or "no artificial preservatives". Certification is essentially aimed at regulating and facilitating the sale of organic products to consumers. Individual certification bodies have their own service marks, which can act as branding to consumers. Most certification bodies operate organic standards that meet the National government's minimum requirements. Some certification bodies, certify to higher standards.

### 29.3 Third party certification process

To certify a farm, the farmer is typically required to engage in a number of new activities, in addition to normal farming operations:

- Study the organic standards, which cover in specific detail what is and is not allowed for every aspect of farming, including storage, transport and sale.
- Compliance — farm facilities and production methods must comply with the standards, which may involve modifying facilities, sourcing and changing suppliers, etc.
- Documentation — extensive paperwork is required, detailing farm history and current set-up, and usually including results of soil and water tests.
- Planning — a written annual production plan must be submitted, detailing everything from seed to sale: seed sources, field and crop locations, fertilization and pest control activities, harvest methods, storage locations, etc.
- Inspection — annual on-farm inspections are required, with a physical tour, examination of records, and an oral interview.
- Fee — an annual inspection/certification fee (currently starting at \$400–\$2,000/year, in the US and Canada, depending on the agency and the size of the operation).
- Record-keeping — written, day-to-day farming and marketing records, covering all activities, must be available for inspection at any time.

In addition, short-notice or surprise inspections can be made, and specific tests (e.g. soil, water, plant tissue) may be requested.

For first-time farm certification, the soil must meet basic requirements of being free from use of prohibited substances (synthetic chemicals, etc) for a number of years. A conventional farm must adhere to organic standards for this period, often, two to three years. This is known as being in *transition*. Transitional crops are not considered fully organic.

Certification for operations other than farms is similar. The focus is on ingredients and other inputs, and processing and handling conditions. A transport company would be required to detail the use and maintenance of its vehicles, storage facilities, containers, and so forth. A restaurant would have its premises inspected and its suppliers verified as certified organic.

## **29.4 Participatory certification**

*“Participatory Guarantee Systems are locally focused quality assurance systems. They certify producers based on active participation of stakeholders and are built on a foundation of trust, social networks and knowledge exchange”* (IFOAM definition, 2008).

Participatory Guarantee Systems (PGS) represent an alternative to third party certification, especially adapted to local markets and short supply chains. They can also complement third party certification with a private label that brings additional guarantees and transparency. PGS enable the direct participation of producers, consumers and other stakeholders in:

- Choice and definition of the standards
- Development and implementation of certification procedures
- Certification decisions

Participatory Guarantee Systems are also referred to as “participatory certification”.

### **29.4.1 History of Participatory Guarantee Systems**

The organic movement has been a pioneer in the implementation and definition of Participatory Guarantee Systems (PGS). Organic certification started in various parts of the world in the 70s and 80s based on associative systems that were very close to what is now called PGS. Some of these associations are still doing participatory certification today, such as for example Nature & Progress in France. Even though third party certification (following ISO 65 requirements) has become the dominant form of certification in the food sector, as well as many other sectors, alternative certification systems have never ceased to exist. In 2004, IFOAM, the International Federation of Organic Agriculture Movements, and MAELA, the Latin American Agroecology Movement, jointly organized the first International Workshop on Alternative Certification that took place in Torres, Brazil. It is at that workshop that the concept of “Participatory Guarantee Systems” was adopted. At this event, an international working group on PGS was established, which later became an official Task Force under the umbrella of IFOAM.

## **29.5 Certification & product labeling**

In some countries, organic standards are formulated and overseen by the government. The United States, the European Union, Canada and Japan have comprehensive organic legislation, and the term "organic" may be used only by certified producers. Being able to put the word "organic" on a food product is a valuable marketing advantage in today's consumer market, but does not guarantee the product is legitimately organic. Certification is intended to protect consumers from misuse of the term, and make buying organics easy. However, the organic labeling made possible by certification itself usually requires explanation. In countries without organic laws, government guidelines may or may not exist, while certification is handled by non-profit organizations and private companies.

In India, APEDA regulates the certification of organic products as per National Standards for Organic Production. "The NPOP standards for production and accreditation system have been recognized by European Commission and Switzerland as equivalent to their country standards. Similarly, USDA has recognized NPOP conformity assessment procedures of accreditation as equivalent to that of US. With these recognitions, Indian organic products duly certified by the accredited certification bodies of India are accepted by the importing countries." In March 2000, the Ministry of Commerce launched NPOP (National Programme for Organic Production) design to establish national standards for organic products which could then be sold under the logo India Organic. For proper implementation of NPOP, NAPP (National Accreditation Policy and Programme) has been formulated, with Accreditation Regulations announced in May 2001. These make it mandatory that all certification bodies whether internal or foreign operating in the country must be accredited by an Accreditation Agency. The regulations make provision for export, import and local trade of organic products. However, currently only the exports of organic products come under government regulations. Thus an agricultural product can only be exported as an organic product if it is certified by a certification body duly accredited by APEDA. Organic crop production, organic animal production, organic processing operations, forestry and wild products are the categories of products covered under accreditation.

## **29.6 Organic certification mark**

### **29.6.1 Organic logo**

A trademark – “India Organic” will be granted on the basis of compliance with the National standards for Organic Production (NSOP). Communicating the genuineness as well as the origin of the product, this trademark is owned by the Government of India. Only such exporters, manufacturers and processors whose products are duly certified by the accredited inspection and certification agencies, will be granted the license to use of the logo which would be governed by a set of regulations.

### **29.6.2 Specifications**

The Indian Organic Logo must comprise of the colour specifications listed below: -

### **29.6.3 Concept of organic logo**

Symbolizing the rhythm of cosmic and earth forces represented by the blue and brown waves of force and energy, ‘India Organic’ logo celebrates the essence of nature. These forces work in harmony upon the earth’s environment and this rhythm is reinforced and supported by the green plant growth. The colours used have a special significance in the logo concept. The cosmic force in blue symbolizes universal purity. Richness of soil, nourished with natural ingredients in organic farming, is symbolized by the earth forces in golden brown. The plant in green uses the colour of nature and natural products untouched by chemicals. The blue background is symbolic of earth’s environment that is congenial for life to thrive in and is also free of pollution and harmful chemicals.

### **29.6.4 Misrepresentation of the term *organic***

The word *organic* is central to the certification (and organic food marketing) process, and this is also questioned by some. Where organic laws exist, producers cannot use the term legally without certification. In the US, motivated by the cost and legal requirements of certification (as of Oct. 2002), the private farmer-to-farmer association, Certified Naturally Grown, offers a "nonprofit alternative eco-labelling program for small farms that grow using USDA Organic methods but are not a part of the USDA Certified Organic program."

## **29.7 Accreditation**

Accreditation is a process in which certification of competency, authority, or credibility is presented. One example of accreditation is the accreditation of testing laboratories and certification specialists that are permitted to issue official certificates of compliance with established standards, such as physical, chemical, forensic, quality, and security standards.

### **29.7.1 Position of Accreditation in India**

As per the National Programme for Organic Production (NPOP) an accreditation refers registration by the accreditation agency for certifying agency for certifying organic farms, products and processes as per the guidelines of the National Accreditation Policy and Programme for Organic Product. NPOP programme in context of Indian accreditation scenario, defined the function of accreditation agencies like

- Prescribe the package of practices for organic products in their respective schedule;
- Undertake accreditation of inspection and certifying agencies who will conduct inspection and certify products as having been produced in accordance with NPOP;
- Monitor inspection made by the accredited inspection agencies;
- Lay down inspection procedures;
- Advise the National Steering Committee on Organic Production;
- Accept Accredited certification programmes if such programme confirm to National Standard;
- Accreditation Agencies Shall evolve accreditation criteria for inspection and/or certifying agencies and programme drawn up by such agencies for their respective area of operation and products;
- Accreditation agencies shall prepare an operating manual to assist accredited agencies to abide by such a manual must contain appropriate directions, documentation formats and basic agency and farm records for monitoring and authentication of adherence to the organic production programme;<sup>70</sup>
- Eligible inspection and certification agencies implementing certification programmes will be identified by the Accreditation Agency.

In the year 2000, Ministry of Commerce, Government of India has launched the NPOP. The following accreditation agencies are designated vide TRADE NOTICE (NO ORG/004/2001) date June13, 2001:

1. Agricultural and Processed Food Product Export Development Authority (APEDA)
2. Coffee Board
3. Spice Board
4. Tea Board



## **LECTURE - 31 & 32**

# **PROCESSING, LABELLING, ECONOMIC CONSIDERATIONS AND VIABILITY, MARKETING AND EXPORT POTENTIAL OF ORGANIC PRODUCTS**

### **31.1 Standards**

- Organic products shall not be protected from mixing with non-organic products.
- The certification programme shall set standards to prevent and control pollutants and contaminants.
- Organic and non-organic products shall not be stored and transported together.
- All cleaning, disinfection shall be regulated by certification programme.

### **31.2 Pest and disease control**

- Preventive measures should be stressed.
- Rely on mechanical, physical and biological methods.
- Irradiation is prohibited.
- Allow those pesticidal substances in the appendices of NSOP.
- In case of doubt ensure no residues are present in organic product.
- Persistent or carcinogenic pesticides and disinfectants are not permitted.

### **31.3 Ingredients, Additives and Processing Aids**

- Water and salt may be used in organic products.
- Minerals, vitamins and similar isolated ingredients shall not be used.
- Preparations of micro-organisms and enzymes commonly used in food processing can be used with an exception Genetically engineered products or microbes.

### **31.4 Processing methods**

- Extraction can only be taken place with water, ethanol, plant and animal oil, vinegar, carbon dioxide, nitrogen and carboxylic acids.
- Filtration substances shall not be made of asbestos.

### **31.5 Packaging**

- The materials used should not affect the organoleptic character of a product.

### **31.6 Labelling**

- Don't include water and salt added in calculations of organic ingredients.
- Inconversion product should be clearly distinguished from label of organic products.
- All raw materials must be listed along with its percentage.
- It should be apparent on the label which raw material is organically certified origin.
- Products should not be labelled as GE or GM.

### **31.7 Storage and transport**

- Organic products are stored in that part of the unit which are certified.
- Bulk stores of organic produce must be kept separately.
- Those areas and transport containers should be cleaned with methods and materials permitted in organic production.

### **31.8 Economic considerations**

- Productivity of farm is less in initial years.
- Yields increases progressively under organic farming.
- The extent of decrease in yields depends on the intensity of external input used before conversion.
- Replacement of external inputs and organic price premium have given mixed results on profitability.

### **31.9 Yield and economics organic and conventional farming**

| Year         | Status             | Yield<br>(q ha <sup>-1</sup> ) | Gross<br>income<br>(₹) | Premium<br>(20%) | Total<br>(₹) | Net<br>income<br>(₹) | Surplus/<br>deficit over<br>conventional |
|--------------|--------------------|--------------------------------|------------------------|------------------|--------------|----------------------|------------------------------------------|
| Conventional | —                  | 10                             | 20,000                 | 0                | 20,000       | 9,000                | 0                                        |
| First year   | Year of conversion | 5                              | 10,000                 | 0                | 10,000       | 750                  | -8,250                                   |
| Second year  | Year of conversion | 5.75                           | 11,250                 | 0                | 11,250       | 3,750                | -5,250                                   |
| Third year   | Organic            | 6.25                           | 12,500                 | 2,500            | 15,000       | 7,000                | -1,500                                   |
| Fourth year  | Organic            | 7.50                           | 15,000                 | 3,000            | 18,000       | 10,500               | 1,500                                    |
| Fifth year   | Organic            | 8.75                           | 17,500                 | 3,500            | 21,000       | 13,500               | 4,500                                    |
| Sixth year   | Organic            | 10.00                          | 20,000                 | 4,000            | 24,000       | 16,500               | 7,500                                    |

### 31.10 Marketing of organic products

- The basic focus of organic farming should be first to produce farm products for the home market and second for export market
- Three types of organic producers in India are
  - Traditional organic growers
  - Commercial farmers
  - Private companies having large farms or organise conversion programmes with growers

**Table 31.1 Major products produced in India by Organic Farming**

|                 |                                                                                                                  |
|-----------------|------------------------------------------------------------------------------------------------------------------|
| Type of Product | Products                                                                                                         |
| Commodity       | Tea, Coffee, Rice, Wheat                                                                                         |
| Spices          | Cardamom, black pepper, white pepper, ginger, turmeric, vanilla, tamarind, clove, cinnamon, nutmeg, mace, chilli |

|            |                                                                     |
|------------|---------------------------------------------------------------------|
| Pulses     | Pigeonpea, blackgram                                                |
| Fruits     | Mango, banana, pineapple, passion fruit, orange, cashew nut, walnut |
| Vegetables | Okra, brinjal, garlic, onion, tomato, potato                        |
| Oilseeds   | Mustard, sesame, castor, sunflower                                  |
| Others     | Cotton, sugarcane, herbal extracts                                  |

**Table 31.2 Indian Organic Overview (2004-2005)**

|                                                  |                             |
|--------------------------------------------------|-----------------------------|
| Area under certified                             | 2.5 M.ha.                   |
| Total certified product                          | 115,238 metric tonnes       |
| Total project certified                          | 332                         |
| Number of processing units                       | 158                         |
| Accredited Inspection and certifying agencies    | 11                          |
| Number of products exported                      | 35                          |
| State ranking 1 <sup>st</sup> in organic exports | Kerala (1232 metric tonnes) |
| All India total organic export                   | 6472 metric tonnes          |
| Premium collected against organic export         | Rs 80.90 crore (tentative)  |

**Table 31.3 Latest production and exports statistics of organic products in India (2015-16)**

|                                                       |                |
|-------------------------------------------------------|----------------|
| Total production of certified organic products (2015) | 1.35 Mt        |
| State having largest area under organic certification | Madhya Pradesh |
| Total volume of export                                | 263,687 Mt     |

|                                        |         |
|----------------------------------------|---------|
| Organic food export realization        | 298 USD |
| Share of export of oilseeds            | 50%     |
| Share of export of processed foods     | 25%     |
| Share of export of cereals and millets | 17%     |
| Share of export of tea                 | 17%     |
| Share of export of pulses              | 2%      |
| Share of export of spices              | 2%      |
| Share of export of dry fruits          | 1%      |

**Table 31.4 Export potential of organic products**

|               |                                                                                                                                                                   |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IFOAQM        | Established in 1972<br>Headquarter in Germany<br>Umbrella for organization organic agricultural association<br>Set up international organic accreditation service |
| CODEX         | Codex alimentarius commission<br>Intergovernmental Body<br>Established in 1962                                                                                    |
| EU Regulation | Laid out a basic regulation for European union organic standards                                                                                                  |
| Demeter       | Demeter International is a world wide network of 19 international certification Bodies<br>in Africa, Australia, Europe                                            |
| JAS           | A set of guidelines Japan Agricultural standards for organic Farming                                                                                              |

