

Farming system

- Farming systems refers deliberate raising of crops, forest and fruit trees, animals including fisheries, piggery and duck farming, sericulture, mushroom, on a given unit of land to increase the productivity and profitability, to upgrade natural resource base and to achieve overall improvement in the environment.
- The philosophy behind shifting from cropping system to the farming system mode involves
 - (i) in situ recycling of organic residues including farm wastes generated at the farm to reduce the dependency on chemicals
 - (ii) decrease in cost of cultivation through enhance input use efficiency,
 - (iii) effective use of bye-products / wastes of one component for the benefit of other component/components
 - (iv) upgrading of soil and water quality and bio-diversity,
 - (v) increased water productivity,
 - (vi) nutritional security through minimizing chemical residues in soil plant animal human chain
 - (vii) environmental security by moderating flow of green house gases from the soil to environment.
- Farming system provides a vast canvass of livelihood gathering, a better risk coping strategy, continuous flow of income and employment throughout the year for small landholders.
- It involves utilization of primary and secondary produce of one system as a basic input of other system through making them mutually integrated.

Concept and principles

- The modern agriculture emphasize too more dimensions viz., time and space concept.
- Time concept relates to increasing crop intensification in situation where there is no constraint for inputs.
- In rainfed areas where there is no possibility of increasing the intensity of cropping, the other modern concept (space concept) can be applied.

- In space concept, crops are arranged in tier system combining two or more crops with varying field duration as intercrops by suitably modifying the planting method.
- Income through arable cropping alone is insufficient for bulk of the marginal farmers.
- Activities such as dairy, poultry, fish culture, sericulture, bio-gas production, edible mushroom cultivation, agro-forestry and agri-horticulture, etc., assumes critical importance in supplementing their farm income.
- It should fit well with farm level infrastructure and ensures fuller utilization of bye-products.
- Integrated farming system is only the answer to the problem of increasing food production for increasing income and for improving the nutrition of small scale farmers with limited resources.
- **Characteristics of farming systems**
- The farming system research activities are to be farmer oriented, system oriented, problem solving approach, inter-disciplinary, compliments mainstream disciplinary research, test the technology in on-farm trials and provides feed back from the farmers.
- The strategy of FSR should emphasize that the research agenda should be determine by explicitly define farmers needs through an understanding of the existing farming systems rather than its perception by the researchers.
- The farming systems research and extension should be dealt in holistic manner on farmers participatory mode with problem solving approach, keeping genders activity, inter disciplinary and interactive approach.
- It should emphasize extensive on-farm activities and complement the experimental on-station research and acknowledges the location specificity of technical solutions and document the inter dependencies among multiple clients.
- Greater importance is placed on feedback to modify the content of subsequent on farm trials, if necessary, by changing research priorities focusing policy shifts based upon micro level analysis. Thus farming system represents an appropriate combination of farm enterprises, viz., cropping systems, horticulture, livestock,

fishery, forestry, poultry and the means available to the farmer to raise them for profitability.

- It interacts adequately with environment without disclosing the ecological and socio-economic balance on one hand and attempts to meet to national goal on others.
- Hence there is a need to do research on farming systems research for sustainable income along with the maintenance of natural resources. It is designed to understand farmers' priorities, strategies and resource allocation decisions.

Methodology to organize farming systems under on-farm conditions

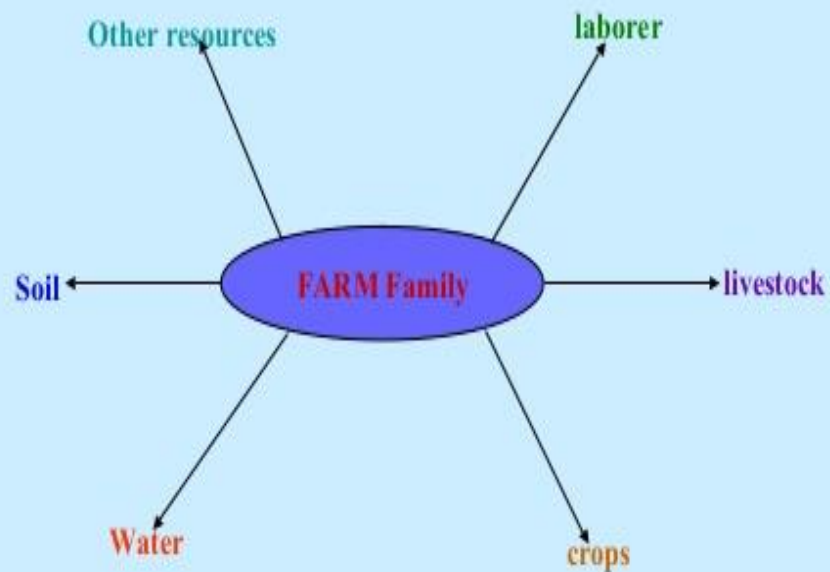
- Farm selection: Select the agro-ecological zone in which FSR is to be initiated. If necessary, further divide this agro-ecological zone to identify specific farming situation.
- Selection of villages and farmers: Select the village in each farming situation comprising marginal / small and medium / large farmers. Selection of village and farmers should be random so as to represent all farming community of the target area.
- Diagnosis of constraints in increasing farm productivity: Carry out survey through rapid rural appraisal. Prepare an inventory of farm resources and support services. Identify the production constraints.
- Research, design and technology generation and adoption Technology transfer and diffusion of improved farming systems within recommended domain.
- Impact of technology of improved farming system – productivity, economic returns, energy input – output, employment, equity (gender issue) and environment.

Predominant components Farming systems

- The different components of farming systems as categorized by Fresco (1986) are universal regardless of type of farming system.
- Land use pattern is an important consideration in farming systems analysis as it describes the behaviour of resource management and allocation of farm activities.
- Among land use pattern interpretations include cropping (or crop) systems and cropping cycles, cultivation systems or land preparation techniques and aspects of allocation of land to different farm activities.

- Livestock system is an integral part of land use pattern and when proper interactions are operating between livestock system, cropping system, the household system and the social and physical environment systems a farming system exists as a single operational entity.

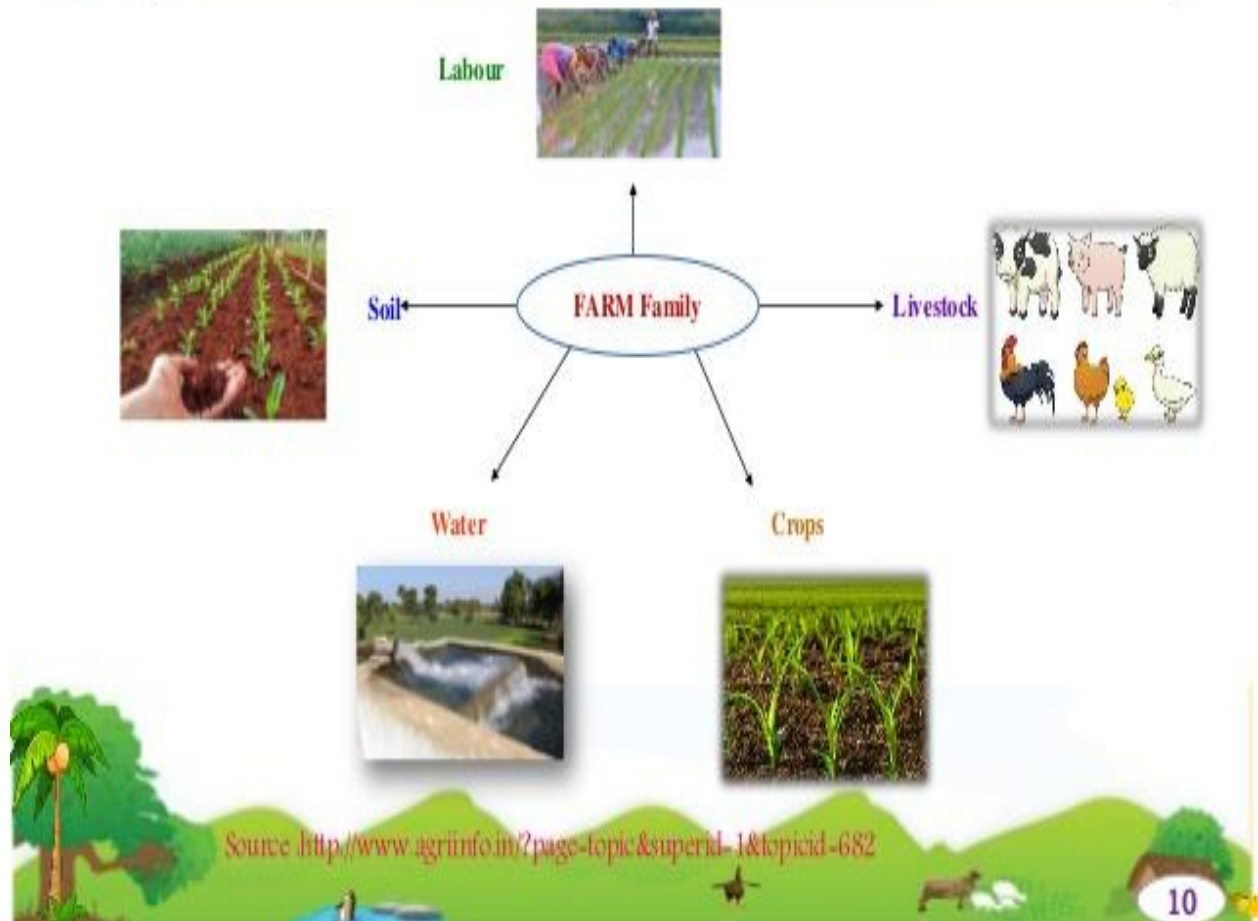
Farming System--components



- Functions with in limitation of capability/resources/socio cultural settings
- Interacting with physical, biological, economic factors
- managing agricultural activity/even non farm vocations



Farming System-Components



- A farming systems framework was used to organize and analyze primary empirical data to track how farming systems in the study areas have evolved over time.
- Such an approach recognizes the biophysical production system, made up of crops, climate, soils etc., the management system, including people, values, goals, knowledge, resources and decision making and the social, economic and institutional context in which they are situated.

- Using such a framework enabled the analysis of the interconnectedness and interdependence of components simultaneously influencing farming systems, yet operating across a range of spatial scales (e.g., climate, labour, markets, knowledge etc.).
- The resources that determine the capacity to respond to change, i.e., system inputs, with properties that demonstrate a system is capable of responding. In the case of farming systems, these properties are productivity, diversity and connectivity.
- Combined, these components are fundamental to overall farming system adaptive capacity.
- Resources, institutions, productivity and diversity provide a framework for analysing how trends in farming system evolution have influenced adaptive capacity.
- In the proposed adaptive capacity framework connectivity, defined as the strength of internal connections, is considered as being part of institutions as it determines interconnectedness between parts of a system.
- Resources refer to the natural, human, financial resources or the assets used as system inputs, for example labour.
- The characteristics of the farming system result in certain system properties, productivity and diversity, which are also interrelated.
- Productivity is the accumulation of resources within a system that ensure it continues to function.
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System

- A system is a group of interacting components, operating together for a common purpose, capable of reacting as a whole to external stimuli: it is unaffected directly by its own outputs and has a specified boundary based on the inclusion of all significant feedbacks.
- For example, the human body is a system-it has a boundary (e.g., the skin) enclosing a number of components (heart, lungs) that interact (the heart pumps blood to the lungs) for a common purpose (to maintain and operate the living body).

- Collection of unrelated items does not constitute a system. A bag of marbles is not a system: if a marble is added or subtracted, a bag of marbles remains and may be almost completely unaffected by the change.
- The marbles only behave as a whole if the whole bag is influenced, for example by dropping it, but if it bursts the constituent parts go their own ways. It is the properties of the system that chiefly matter and they may be summarized in the phrase 'behavior as a whole in response to stimuli to any part'.
- Ecosystem: Any collection of organisms that interact or have the potential to interact along with the physical environment in which they live, form an ecological system or ecosystem.
- Ecosystems are not static entities they are dynamic systems with characteristic pattern of energy flow, nutrient cycling and structural change. Agro-ecosystem: Agro-ecosystems are ecological systems modified by human beings to produce food, fibre or other agricultural products.
- Like the ecological systems they replace, agro-ecosystems are structurally and dynamically complex. But their complexity arises from the interaction between socioeconomic and ecological processes.
- Crop system: An arrangement of crop populations that transform solar energy, nutrients, water and other inputs into useful biomass ie. food, feed, fuel and fibre. Crop system comprised of soils, crop, weed, pathogen and insect subsystems. The crop can be of different species and variety, but they only constitute one crop system if they are managed as a single unit.
- The crop system is a subsystem of cropping system. For example, in the maize crop system, maize is the dominant crop which is grown in association with other crops.
- Cropping Systems: Cropping systems, an important component of a farming system, represents a cropping pattern used on a farm and their interaction with farm resources, other farm enterprises and available technology, which determine their make up. It is defined, as the order in which the crops are cultivated on a piece of land over a fixed period or cropping system is the way in which different crops are grown.

- In the cropping systems, sometimes a number of crops are grown together or they are grown separately at short intervals in the same field.
- Cropping Pattern: It is the pattern of crops for a given piece of land or cropping pattern means the proportion of area under various crops at a point of time in a unit area or it indicated the yearly sequence and spatial arrangements of crops and follows in an area.
- Difference between cropping pattern and cropping system

| cropping pattern | cropping system |
|--|--|
| Crop rotation practiced by a majority of farmers in a given area or locality. | Cropping pattern and its management to derive benefits from a given resource base under specific environmental conditions. |
| Type and management of crops in time and space. | The cropping patterns used on a farm and their interaction with farm resources, other farm enterprises and available technology which determine their make up. |
| Yearly sequence and spatial arrangement of crops or crops and fallow on a given area. The proportion of area under various crops at a point of time in a unit area | Pattern of crops taken up for a given piece of land, or order in which crops are cultivated on a piece of land over a fixed period, associated with soil, management practices such as tillage manuring and irrigation |

- Land resources being limited emphasis have to be placed for increasing production from unit area of land in a year.
- 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 for cattle and generate sufficient cash income for domestic and cultivation expenses. This objective could be achieved by adopting intensive cropping.
- Methods of intensive cropping include 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 agricultural activities.
- These problems can be overcome by making modification in the cropping techniques.
- Alteration in crop geometry may help to accommodate intercrops without losing the base crop production.
- Efficient Cropping Systems: Efficient cropping systems for a particular farm depend on farm resources, farm enterprises and farm technology because farm is an organized economical unit.
- The farm resources include land, labour, water, capital and infrastructure. When land is limited intensive cropping is adapted to fully utilize available water and labour.
- When sufficient and cheap labour is available, vegetable crops are also included in the cropping systems as they require more labour.
- Capital intensive crop like sugarcane, banana, turmeric etc. find a space in the cropping system when capital is not a constraint.
- In low rainfall regions (750 mm/annum) mono cropping is followed and when rainfall is more than 750 mm, intercropping is practiced.
- With sufficient irrigation water, triple and quadruple cropping is adopted.
- When other climatic factors are not limiting farm enterprise like dairying, poultry etc. also influence the type of cropping system.
- When the farm enterprises include dairy, cropping system should contain fodder crops.
- Components change in cropping system also takes place with the developments of technology.

- The feasibility of growing for crop sequences in Genetic alluvial plains inputs to multiple cropping.
- Importance of systems approach In system approach all the components and activities are linked, they affect each other.
- It is not sensible to look at one component by itself without recognizing that what it does and what happens to it will affect other parts of the system.
- For example consider what happens when you stub your toe: the whole body may react and different parts may respond differently.
- Eyes may water, the voice may make appropriate sounds, the pulse rate may increase and hands may try to rub the damaged toe.
- It would be very rash to alter any component of a system without regard to the consequences and reactions elsewhere.
- You cannot, for example, improve a car (system) by doing research on one wheel and then making it rather bigger than the rest. Or increase the power and size of the engine without regard to the ability of the chassis to support it.
- These things are common sense in such familiar contexts- they also apply to biological and agricultural systems. In agriculture, management practices were usually developed for individual crop.
- However, farmers are cultivating different crops in different seasons based on their adaptability to a particular season, domestic needs and profitability.
- Therefore, production technology or management practices should be developed in view all the crops grown in a year or more than one year if any sequence or rotation extends beyond one year.
- Such a package of management practices for all crops leads to efficient use of costly inputs, besides reduction in production cost.
- For instance, residual effect of manures and fertilizers applied and nitrogen fixed can considerably bring down the production cost if all the crops are considered than individual crops.
- In this context, cropping system approach is gaining importance.
- Physical resources, soil and water management in cropping systems The objective of any cropping system is efficient utilization of all resources viz. land, water and

solar radiation, maintaining stability in production and obtaining higher net returns.

- The efficiency is measured by the quantity of produce obtained per unit resource used in a given time.
- The objective of traditional agriculture was to increase the production by two means: a. by increasing area under cultivation b. by increasing the productivity per unit area of the crop.
- But two more dimensions are added to modern agriculture
- a. to increase the production per unit time.
- b. to increase the production per unit space.
- In the traditional cropping systems, mixtures and rotations were developed by the farmers over years of experience by trial and error to suit specific ecological and sociological conditions to attain yield stability,
- whereas modern scientific cropping has three pillars, viz. (i) Genotype, (ii) Geometry of planting and (iii) Genotype means genetic makeup of seed.
- 2. Geometry of planting means: a. Shape of planting pattern on the land surface. b. Space of the area for the individual plant.
- Geometry of planting may be circular, rectangular, square type or cubical. It is indirectly related to plant population.
- Cubical pattern of planting has maximum plant population. Plant population may be defined as (i) size of area available to the individual plant, (ii) number of plants per unit area.
- 3. Management practices include all the practices of crop production. For the cropping system, management includes a. Type and arrangement of crops in time and space i.e. cropping pattern. b. Choice of variety. c. Method of stand establishment. d. Pest management and harvest.
- **Agronomic considerations for different cropping system**
- are different due to inclusion of more than one crop as in intercropping or sequence cropping system.

- Thus, principles involved in management of intercropping system and sequence system are different. Management of Intercropping Systems In intercropping system crops are grown simultaneously.
- Management practices aim to provide favorable environment to all the components, exploit favorable interaction among the component crops and minimize competition among the components.
- a. Seedbed Preparation: The objective of land preparation is to establish an ideal zone for the seedling that minimizes the stress. Potential stress condition include inadequate or excess moisture, unfavorable temperature for a given species, soil crusting, weeds, residue of preceding crop and insect or pathogen attack. Important of seedbed is the same in both conventional (monoculture) and in multiple cropping.
- Seedbed preparation depends on the crop. Deep rooted crops responds to deep ploughing while for most of cereal shallow tillage is sufficient. The crops with small seed require fine seedbed, cotton, and maize, planted on ridges, certain crops on flat seedbed. Since more than one crop is planted in intercropping, the seedbed is generally prepared as per the needs of base crop.
- Sugarcane planted in furrow and intercrop sown on ridges. In Groundnut + red gram intercropping system, flat seedbed is prepared for sowing crops. However, ICRISAT is recommending broad bed and furrow for black soils. In rice + maize intercropping system, ridges and trenches are formed.
- Maize is planted on ridges and rice in trenches.
- b. Varieties: The varieties of component crop in intercropping system should be less competitive with the base crop and peak nutrient demand period should be different from the base crop.
- Minimum difference between the maturity periods of two components should be of 30 days. Hybrids varieties of sorghum like CSH - 6, CSH - 9 are suitable for intercropping with long duration variety of red gram like C11 and LRG 30 because of wider gap between maturity periods.
- The varieties selected for intercrop should have thin leaves, tolerant to shading and less branching. 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 the base crop should be as in sole crop.

- Sowing: Practices of sowing are slightly altered to accommodate inter - crop in such a way that it cause less competition to the base crop.
- Widening inter row spacing of cereal component to accommodate more rows of component legume crop improves legume yield and efficiency of the intercrop system.
- Sowing of base crop is done either as paired row, paired – wider row or skip row of base crop are brought close by reducing inter row spacing.
- The spacing between two pairs of rows is increased to accommodate the inter crop. Such row arrangement of base crops within the rows improves the amount of light transmitted to the lower component crop, which can enhance legume yield in cereal + legume intercropping system. For example – the normal row spacing in Rainfed cultivation is 30 cm.
- The row spacing is reduced to 20 cm between paired rows and 50 cm spacing in two pairs.
- The spacing in paired row planting designed as 20/50 cm indicates that the spacing between two rows in pairs is 20 cm and among the pairs 50 cm.
- Similarly, pearl millet is planted with row spacing 30/60 cm in paired row planting.
- These changes in crop geometry do not alter the yield of base crop, but intercrops are benefited to some extent.
- When alternating pairs of sorghum rows 90 cm with two rows of an associated legume, Singh (1972) found that LER was greater compared at 60 cm between rows with two rows of the legume in between.
- Planting in fixed ratio of intercrop is most common. The intercropping system of groundnut + red gram is either in 5:1 or 7:1 ratio and sorghum + red gram in 2:1 ratio. In these cases the normal three tined or four tined seed drill can be used without any modification.
- The hole(s) pertaining to intercrop row in the hopper is(are) closed with a piece of cloth in that row, intercrop is sown with alkali or kera.

- For higher yields, base crop population is maintained at its sole crop population and intercrop population is kept at 80 percent of its sole crop population.
- Relative sowing time of component crop is important management variable manipulated in cereal + legume intercropping system but has not been extensively studied. Sowing may be staggered to increase the temporal difference, which might result in higher yield advantage (Singh et al.1981).
- d. Fertilizer Application: The nutrient uptake is generally more in intercropping system compared to pure crops. When the legume is associated with a cereal crop in intercropping system, legume supplement a portion of nitrogen required of cereal crop; the amount may be of 20 kg/ha by legumes.
- Application of higher dose of nitrogen to the cereal + legume intercropping system not only reduce the nitrogen fixation capacity of legumes, but also growth of the legume is suppressed by aggressive fast growth of cereals.
- Cereal + legume intercropping, therefore is 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 cereal + legume or legume + legume.
- With regards 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 crops to meet the extra demand.
- Basal dose of nitrogen is applied to rows of both components in cereal + legume inter crop.
- Top dressing of nitrogen is done only in cereal rows. P & K are applied as basal dose to both crops.
- e. Water Requirement: The technique of water management is the same for sole cropping and intercropping or sequential cropping.
- However, the presence of an additional crop may have an important effect on evapo - transpiration. With proper water management, it is possible to grow two crops where normally only one crop is raised under rain fed condition. Intercropping system is generally recommended for rain fed situations to get the stable yields.

- The total water requirement of intercrop does not increase much compared to sole cropping. At ICRISAT, the water requirement of sole sorghum and intercropping with red gram was almost similar (584 and 585 mm, respectively).
- However in a more competitive crop like onion as intercropped in groundnut increase the total water requirement by about 50 mm.
- The total water used in intercropping system is almost same as in sole crops, but yields are increased.
- Thus water use efficiency of intercropping is higher than sole crops.
- Scheduling of water: If one of the crop is irrigated based on its requirement, the other crop may suffer due to excess water stress, sometimes leading to total failure of crop. In cotton + black gram intercropping system, cotton is irrigated once in 15-20 days.
- The intercrop black gram is often affected by excess water and gives poor yield. In such situations, skip furrow method of irrigation is advocated. Scheduling irrigation at IW/CPE ratio of 0.60 to 0.80 or irrigation at one bar soil moisture tension is suitable for most of the systems.
- f. Weed Management: Generally it is believed that intensive cropping reduces weed problems. Weed infestation depends on the crop, plant density and cultural operation done.
- Weed problems is less in intercropping system compared to the sole crops. This is due to complete crop cover because of high plant density in intercropping which cause severe competition with weeds and reduce weed growth.
- The weed suppressing ability of intercrop is dependent upon the component crops selected, genotype used, plant density adopted, proportion of component crops, their spatial arrangement and fertility moisture status of the soil.
- Experiment carried out at ICRISAT, Hyderabad, indicated that there was 50 - 75 % reduction in weed infestation by intercropping. Pigeon pea + sorghum intercropping system, which is extensively practiced in Karnataka, M.S and A.P is known to reduce weed intensity.
- The higher plant population and complete covering of the soil earlier in intercropping system reduce weed infestation. In late maturing crops that are

planted in wide rows, presence of early maturing crops helps to cover the maturing crops that are planted at wide rows.

- Presence of early maturing crops helps to cover the vacant inter-row space and keeps weed under check.
- Quick growing noncompetitive, compact legumes like green gram and black gram act as another crop due to their good canopy coverage. In certain situations, intercrops are used as biological agents to control weeds.
- Black gram, green gram, cow pea in sorghum and cowpea in banana reduce weed population. 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. Weed infestation in intercropping is influenced by early growth and competitive additives of the component crops.
- If one or both the component crops are vigorous and cover the land area rapidly, weed infestation is greatly reduced.
- Early crop canopy to cover the soil is more important than rapid increase in plant height. It is well known that, different species of weeds are associated with different crops, but weeds present in sole crops are different than those present in intercropping system.
- At Hyderabad, in pearl millet as sole crop mixed weed flora was observed as Celosia, Digitaria and Cupreous in sole crop of groundnut.
- In pearl millet + groundnut intercropping system type of weeds changes with proportion of component crops.
- As more rows of groundnut are introduced in place of pearl millet of rows, there is a striking increase in both numbers and biomass of the tall and competitive Celosia, especially in groundnut rows.
- Weed problem is less; weed control is necessary in intercropping system. But labour required for weeding is less; second weeding is not necessary because of crop coverage and limited weed growth.

- Normally two hand weeding are required, but it may restrict to one hand weeding under intercropping in sorghum + red gram or sorghum + cowpea.
- Just one weeding is sufficient to get high yield as in weed- free check.
- The critical period of weed free condition may be extended a little longer in intercropping than in sole cropping.
- This is because the critical growth stages of the component crops vary temporally in intercropping. For example, critical weed free period has to be extended to first 7 weeks in sorghum + red gram intercropping while sole sorghum crop requires only 2- 4 weeks weed free period.
- Chemical weed control is difficult in intercropping system because the herbicide may be selective to one crop but non- selective to another. Atrazine control weeds in sole sorghum, but it is not suitable for sorghum + red gram intercropping system, as it is toxic to red gram.
- Herbicides suitable for intercropping systems as- * Maize + green gram & Maize + cowpea. Butachlor (pre - emergence) (Machete) * Sorghum + pulse – fluchloralin (PPI) (Basalin) or Alachlor (pre - emergence) (Lasso) * Sorghum + red gram – prometryne (pre- emergence) * Sugarcane + groundnut – nitrofen (pre-emergence) (TOK E -25).
- g. Pest and Disease in Intercropping System: Pest and diseases are believed to be less in intercropping system due to crop diversity than sole crops. Some plant combination may enhance soil fungicide and antibiotics through indirect effects on soil organic matter content.
- The spread of the diseases 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 infestation is less on Brinjal. Non – host plant in mixtures may emit chemicals or odor that affects the pests, thereby protecting host plants.
- The concept of crop diversification for the management of nematode population has been applied mainly in the form of decoy and trap crops.

- Decoy crops are non-host crops, which are planted to make nematode waste their infection potential. This is affected by activating larva of nematode in the absence of hosts by the decoy crops.
- INTENSIVE CROPPING
- Principles
- The turn around period between one crop and another is minimised through modified land preparation.
- It is possible when the resources are available in plenty. Ex. Garden land cultivation.
- Cropping intensity is higher in intensive cropping system.
- Crop intensification technique includes intercropping, relay cropping, sequential cropping, ratoon cropping, etc.
- All such systems come under the general term multiple cropping.
- Need for intensive cropping
 - • Cropping systems has to be evolved based on climate, soil and water availability for efficient use of available natural resources.
 - • The increase in population has put pressure on land to increase productivity per unit area, unit time and for unit resource used.
 - • This cropping system should provide enough food for the family, fodder for cattle and generate sufficient cash income for domestic and cultivation expenses.
- Intensive cropping: Growing number of crops on the same piece of land during the given period of time.
- Cropping intensity: Number of crops cultivated in a piece of land per annum is cropping intensity. In Punjab and Tamil Nadu, the cropping intensity is more than 100% (i.e. around 140- 150%).
- In Rajasthan, the cropping intensity is less. Multiple cropping: The intensification of cropping in time and space dimensions.
- Growing two or more crops on the same field in a year. Forms of multiple cropping Intercropping: Growing two or more crops simultaneously on the same field.
- Crop intensification is in both time and space dimensions.

- There is intercrop competition during all or part of crop growth.
- (a) Mixed intercropping: Growing two or more crops simultaneously with no distinct row arrangement. Also referred to as mixed cropping. Ex: Sorghum, pearl millet and cowpea are mixed and broadcasted in rainfed conditions.
- (b) Row intercropping: Growing two or more crops simultaneously where one or more crops are planted in rows.
- Often simply referred to as intercropping. Maize + greengram (1:1), Maize + blackgram (1:1), Groundnut + Redgram (6:1)
- (c) Strip intercropping: Growing two or more crops simultaneously in strips wide enough to permit independent cultivation but narrow enough for the crops to interact agronomically. Ex. Groundnut + redgram (6:4) strip.
- (d) Relay intercropping: Growing two or more crops simultaneously during the part of the life cycle of each. A second crop is planted after the first crop has reached its reproductive stage of growth, but, before it is ready for harvest.
- Often simply referred to as relay cropping. Rice- rice fallow pulse.
- Advantages of intercropping
 - • Better use of growth resources including light, nutrients and water • Suppression of weeds
 - • Yield stability; even if one crop fails due to unforeseen situations, another crop will yield and gives income
 - • Successful intercropping gives higher equivalent yields (yield of base crop + yield of intercrop), higher cropping intensity
 - • Reduced pest and disease incidences
 - • Improvement of soil health and agro-eco system
- Sequential cropping: Growing two or more crops in sequence on the same field in a farming year.
- The succeeding crop is planted after the preceding crop has been harvested. Crop intensification is only in time dimension.
- There is no intercrop competition. (a) Double, triple and quadruple cropping: Growing two, three and four crops, respectively, on the same land in a year in sequence.

- Ex. Double cropping: Rice: cotton;
- Triple cropping: Rice: rice: pulses;
- Quadruple cropping: Tomato: ridge gourd: Amaranthus greens: baby corn
- (b) Ratoon cropping: The cultivation of crop re-growth after harvest, although not necessarily for grain. Ex. Sugarcane: ratoon; Sorghum: ratoon (for fodder).
- The various terms defined above bring out essentially two underlying principles, that of growing crops simultaneously in mixture, i.e., intercropping; and of growing individual crops in sequence, i.e., sequential cropping.
- The cropping system for a region or farm may comprise either or both of these two principles.
- **SUSTAINABLE AGRICULTURE** Definition: A farming systems that are "capable of maintaining their productivity and usefulness to society indefinitely and must be resource-conserving, socially supportive, commercially competitive, and environmentally sound."
- **USDA (legal)** Sustainable agriculture means, an integrated system of plant and animal production practices having a site-specific application that will, over the long term:
 - satisfy human food and fiber needs;—
 - enhance environmental quality and the natural resource based upon which the agricultural— economy depends; make the most efficient use of nonrenewable resources and on-farm resources and—
 - integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations;—
 - enhance the quality of life for farmers and society as a whole.— Advantages
 - Production cost is low—
 - Over all risk of the farmer is reduced—
 - Pollution of water is avoided—
 - Very little or no pesticide residue is ensured— Ensures both short and long term profitability—

- Disadvantages Since sustainable agriculture uses least quantum of inputs, naturally the output (yield) may also be less.
- Major components of sustainable agricultural system • Soil and water conservation to prevent degradation of soil productivity •
- Efficient use of limited irrigation water without leading to problems of soil salinity, alkalinity and high ground water table •
- Crop rotations that mitigate weed, disease and insect problems, increase soil productivity and minimise soil erosion
- • Integrated nutrient management that reduces the need for chemical fertilizers improves the soil health and minimise environmental pollution by conjunctive use of organics, in-organics and bio-fertilizers.
- • ‘Integrated pest management that reduces the need for agrochemicals by crop rotation, weather monitoring, use of resistant cultivar, planting time and biological pest control.
- • Management system to control weed by preventive measures, tillage, timely inter cultivation and crop rotation to improve plant health.
- INTEGRATED FARMING SYSTEM (IFS) Integration of two or more appropriate combination of enterprises like crop, dairy, piggery, fishery, poultry, bee keeping etc., for each farm according to the availability of resources to sustain and satisfy the necessities of the farmer
- Definition: A farming system is a collection of distinct functional units such as crop, livestock, processing, investments and marketing activities which interact because of the joint use of inputs they receive from the environment which have the common objective of satisfying the farmers’ (decision makers) aims.
- The definition of the borders of the options depends on circumstances; often it includes not only the farm (economic enterprise) but also the household (farm – household system)” Possible enterprises Wetland based farming system
- • Crop + Fish + Poultry/poultry/pigeon • Crop + Fish + Mushroom Gardenland based farming system Crop + Dairy + Biogas→
- Crop + Dairy + Biogas + Sericulture→
- Crop + Dairy + Biogas + Mushroom + Sylvi-culture→

- Dry land based farming system Crop + Goat + Agroforestry—
- Crop + Goat + Agroforestry + Horticulture—
- Benefits of IFS
- Higher Productivityλ
- Profitabilityλ
- Sustainabilityλ
- Balanced foodλ
- Recycling reduces pollutionλ
- Money round the yearλ
- Employment generationλ
- Increase input efficiencyλ
- Standard of living of the farmer increasedλ
- Better utilisation of land, labour, time and resourcesλ

Interaction

- ✓ When different crops are grown in association as in intercropping or in sequence some kind of interaction may occur.
- ✓ The interaction is mainly due to response of one species to the environment as modified by the presence of another species.
- ✓ Types of Interactions:—
- ✓ I. Competitive interaction:- One type of species may have greater ability to use the limiting factor of the other species is called as competitive or interference interaction.
- ✓ II. Non-competitive interaction:- When the crops are grown in association and the growth of either of the concerned species is not affected, the interaction is termed as noncompetitive interaction.
- ✓ III. Complementary interaction:- If one type of species is able to help the other type is called as complementary interaction.
- ✓ IV. Allelopathy:- Interaction may also occur in some other manner by way of producing toxic chemicals and affect the establishment of growth of the associated species is called as allelopathy. a) e.g.

- ✓ The toxic chemicals left in the soil by roots of sunflower crop inhibits the germination of succeeding crop.
- ✓ b) The stubbles of crops like sorghum, maize, rice husk and sugarcane straw which have high C:N ratio causes immobilization of nitrogen.
- ✓ This creates the deficiency of nitrogen in the early stage of succeeding crop.
- ✓ c) However, roots and the residues of legume crops adds nitrogen in the soil.

A) Interactions in Intercropping System:-

- ✚ Solar radiation:- The quantity of energy potentially available for photosynthesis which is captured by a crop canopy is called as Absorbed Photosynthetically Active Radiation (APAR).
- ✚ Intercropping can increase the light interception by as much as 30-40%.]
- ✚ In intercropping system having taller and shorter components.]
- ✚ The taller components intercept most of the solar radiation while shorter component] suffers or it requires shading or high humidity condition.
- ✚ The taller components have erectophile(vertical) leaf canopy and shorter] components are planophile (horizontal).
- ✚ Due to erectophile crop canopy it intercept more solar radiation due to canopy are] parallel to solar radiation.
- ✚ The radiations are equally distributed to every leaf canopy without shading effect. But in case of shorter components (i.e. pulse crop) having leaf canopy are right] angle (90°) to solar radiation it occurs the shading effect and finally affect the photosynthesis.
- ✚ In some intercropping systems solar radiation is utilized efficiently by both the crops.
- ✚ In Ground nut + P. pea intercropping system, light interception is prolonged as] pegen pea starts growing after the harvest of groundnut.
- ✚ Light interception also varies according to age of crop, canopy arrangement of crop,] its growth as well as management practices etc.
- ✚ 2. Water and Nutrients:-
- ✚ Water and nutrients are mainly taken up by the roots of the crops.

- ✚ • Competition of water and nutrients between component crops in intercropping system often occurs.
- ✚ Competition for water and nutrients two main types of effects on the less successful or suppressed component.
- ✚ In intercropping systems (Sorghum + Pigeon pea) consists of shallow rooted (Sorghum) and deep rooted (Pigeon pea) components.
- ✚ Deep rooted species (Pigeon pea) extracts moisture and nutrients from deeper layers and supply to the Sorghum crop.
- ✚ Pigeon pea fixes the atmospheric nitrogen into soil and supply to sorghum crop. Also adds organic matter into soil and improves the water holding capacity as well as microbial activity and finally enhances the soil fertility and yield.
- ✚ Sorghum crops supply P and Si to the P. pea crop, it helps to increase the atmospheric N fixation in soil.
- ✚ The non-legume (cereal crop) crop takes large quantity of other nutrients like P, K, S and provide to legume crop.
- ✚ Pigeon pea is long duration crop and deep root system and sorghum is short duration and shallow root system that's why there is no competition among the water and nutrients.
- ✚ 3. Allelopathy:- Any direct or indirect harmful effect that one plant has on another through the production of chemical substances or toxins into the root environment is called as Allelopathy.
- ✚ Such allelopathic compounds get out of plants by volatilization, exudation from roots, leaching from plants or residues by rain or decomposition of residues.
- ✚ Such crops are not suitable either for intercropping or sequential cropping. Sunflower affects the associated crop through the release of allelopathic chemicals in the soil by roots.
- ✚ It inhibits the germination of crop.
- ✚ The residues of sunflower also produce allelochemicals during decomposition.
- ✚ If the sufficient time period of 15-20 days is allowed to lapse between harvest of sunflower and sowing of next crop.

✚ Types of Allelopathy:--

✚ I. True allelopathy:- The direct or indirect harmful effect on the other crops through the release of toxic substances as such from the plant.

✚ II. Functional allelopathy:- When precursor is released which is converted into active substance by some micro-organisms.

✚ Allelopathy observed in two ways:--

✚ I. Allo-inhibition:- The chemical substance released by one species may inhibit species of plants other than one releasing it.

✚ II. Auto-inhibition:- The toxins may inhibit more strongly plants of the producer species itself.

✚ Allelo-chemicals:- The chemicals released by the plant which show allelopathy is called as allelo-chemicals.

✚ a. Many plants exude organic substances from the roots and some of these root exudates acts as allelochemicals inhibiting the growth of associated plant.

✚ b. Living roots of walnut, cucumber and peach are known to exude toxic substances which inhibit the growth of plant growing near them.

✚ 4. Annidation:- It refers to complementary interaction which occurs in space and time.

✚ a) Annidation in space:-

✚ i. The leaf canopies of component crops may occupy different vertical layers as in multistoried and intercropping system.

✚ ii. The taller components tolerates strong light and high evaporative demand and the shorter component favouring shade and high relative humidity.

✚ iii. Thus one component helps the other.

✚ iv. The root system of component crop exploit nutrients from different layers of soil thus utilizing resource efficiently.

✚ v. Generally the crops having varied root system should be grown in intercropping system as in sorghum (shallow) + redgram (deep rooted).

✚ b) Annidation in time:- i. When two crops of widely varying duration are planted, their peak demands for light and nutrients are likely to occur at different periods thus competition is reduced.

- ✚ ii. In Sorghum + Redgram, Maize + Green Gram, Castor + Cowpea intercropping system, when early maturing crops are harvested, the condition becomes favourable for the late maturing crop to make its full growth.

✚ 5. Other Complementary Effects:-

- ✚ i. In an intercropping system generally legume and non-legumes are grown in association. ii. The part of N fixed by the root nodules of legume may become available to the nonlegume component.
- ✚ iii. 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 the associated species also.
- ✚ iv. In Coconut + Black Pepper, Arecanut + Black Pepper and Maize + Bean, one species provides the physical support (Climber) to another thus increasing the yield of climber species.
- ✚ v. The taller components also act as wind barriers protecting the shorter components from lodging.

✚ B. Interaction in Sequential Cropping System:-

✚ 1. Solar Radiation:-

- ✚ i. In sequence cropping, the main objective is to harvest as much as solar radiation per unit area and time.
- ✚ ii. Competition for photosynthetically active radiation does not occur when sole crops are grown in sequence.
- ✚ iii. Longer field duration and rapid ground coverage by canopy is important for efficient utilization of solar radiation.
- ✚ iv. In sequence cropping crops are raised one after another to keep the land occupied by the crop for longer period.

✚ 2. Effect of Preceding crop on the Succeeding crops:-

- ✚ a. In sequence cropping, the preceding crop has considerable influence on the succeeding crop mainly due to changes in soil conditions, presence of allelopathic chemicals, shift in weeds and carry over effects of fertilizers, pest and diseases.

- ✚ b. Temporary immobilization of N due to wide C:N ratio of the residual field operations becomes different after rice crop since soil structure is destroyed due to puddling.
- ✚ c. The previous leguminous crop leaves considerable amount of nitrogen for succeeding crop.
- ✚ d. Phosphorus applied to previous crop is available for the succeeding crop.
- ✚ e. Crops like sorghum and sunflower leaves toxic chemicals in the soil which do not allow germination of succeeding crop.
- ✚ f. Weed number and species differ in the succeeding crop due to effect of previous crop. g. Wheat crop that follows rice suffers from high density of weed *Phalaris minor*.
- ✚ h. The pests and diseases in crop stubbles and another residues of previous crop may infect the succeeding crop.
- ✚ Therefore crop rotation is beneficial in many ways including management of soil fertility, crop pests and soil physical and biological properties.
- ✚ 1) Legume Effect:-
 - ✚ Legume fixes atmospheric N in root nodules and improves the soil status in respect of N.
 - ✚ Legume absorbs soil P more efficiently and part of this mobilized P in organic form is available to the succeeding crop.
 - ✚ The crop residues and the root nodules of legume release N during decomposition for the use of succeeding crop.
 - ✚ Legumes when grown as intercrop save 25% N. Legumes have greater CEC than cereals.
- ✚ 2) Cotton Effect:- Cotton feeds in the deeper layer of soil and removes comparatively smaller quantities of nutrients.
 - ✚ Maize yields well after cotton.
 - ✚ Raising cotton and green gram in summer increased the yield of following rice. Sowing cotton in ragi stubbles improved the yield and N uptake of cotton.
- ✚ 3) Sorghum Effect:-
 - ✚ Nutrient status of soil is exhausted by any fast growing cereal.

- ✚ The crop residues of cereal having wide C:N ratio takes more time for decomposition.
- ✚ During decomposition, soil N is temporarily immobilized.
- ✚ The effect is more pronounced in low fertile soil causing temporary deficiency of N for succeeding crop.
- ✚ Under such condition 25% more nitrogen is to be applied to succeeding crop.
- ✚ This hastens the process of decomposition and overcomes the immobilized N.
- ✚ 4) Overall effects of competition:-
- ✚ The competition is classified under three broad categories.
 - ✚ • i) Mutual inhibition:- The actual yield of each species is less than expected.
 - ✚ ii) Mutual co-operation:- The yield of each species is greater than expected.
 - ✚ iii) Compensation:- One species yield less and the other more than expected.
- ✚ Dominant Species:- Are those species which yield, more than expected and—believed to have greater competitive ability.
- ✚ Dominated Species:- Are less competitive species in a competition.—

Cropping Scheme

Definition

Cropping scheme is a farm budget prepared in advance of a cropping season of the year showing the details farm activities during the proposed year.

Utility

1. To prepared the farm budget for a particular financial year.
2. To predict the expected profit or loss.
3. To prepare the tentative plan of work during proposed year.

4. To determine the total amount quantity of inputs.

5. Input to require and to know in advance.

Importance

1. It indicates the cost of seasonal and varietal cultivation.

2. For proper management of land, labour and capital.

3. It assist in proper functional planning.

4. It assists in calculation of actual net profit.

5. It assists the maintenance of proper farm functions.

6. It assists the preparation of the crop calendar in actual time.

7. It helps in calculating the cultivation and noncultivation costs.

8. It illustrates the essential elements of a farm.

9. It illustrates the normal and abnormal condition of farm.

10. It allows calculations of the profit or loss of future crops.

Principles of preparation

1) Consultation should be made of a map, indicating the farm layout such as roads, ponds, irrigation facilities, number of plots and area etc.

- 2) Varieties of crop should be selected in accordance with local and national requirements.
- 3) Proper crop rotation should be followed for maintaining soil fertility and for controlling pest and disease.
- 4) Green manuring crop should be cultivated for organic matter.
- 5) A particular place should be earmarked for animal husbandry.
- 6) Irrigation and drainage facilities should be checked and made adequate for the cropping scheme.
- 7) Commercial crops should be considered.
- 8) Last years application of fertilizer and its residual effect should be considered.
- 9) A source of capital should be secured.

➤ **Sustainable Agriculture and Natural Resources**

- Sustainable crop production refers to agricultural production in such a way that does not impose any harm to environment, biodiversity, and quality of agricultural crops. Producing crops sustainably increases the ability of the system to maintain stable levels of food production and quality for long term without increasing the demand and requirements of agricultural chemical inputs to control the system. Sustainable crop production deals with keeping the soil alive with organic matter, integrated pest management and reduction in usage of pesticides, protecting biodiversity, ensuring food safety and food quality, improving nutrient quality, and fertilizing the soil with organic fertilizers. Sustainable agricultural production leads to lowering of greenhouse gas emission and carbon footprint of overall world. Sustainably produced crops and food are more beneficial to consume by humans as compared to commercial crops. Sustainable usage of resources ensures the pollution-free environment for our future generations.

- Sustainable approaches should be designed to use agricultural residues of food crops and feed crops for production of biofuel and biodiesel.
- The goal of sustainable agriculture can be attained with the use of 50 % leftover biological residues of food crops and fodder crops in biofuel production.
- This will not only reduce the quantity of land covered by cash crops, but also perform a two-in-one function.
- 2.1 Pest Management Looking back into the history, it was for the thousands of years that tillage and agriculture were considered the same thing. It was never in practice to grow crops before tilling for weeds in the soil.
- As the technology grew, it gifted green revolution which provided farmers with an opportunity to cultivate crops without tilling. It was due to the advent of herbicides and weedicides. Every new invention has some benefits and some associated disadvantages. Same goes for herbicides in particular and pesticides in general.
- It was the use of pesticides that led to environmental pollution and degrading of soil (Triplett and Dick 2008). To avoid the potential harmful effects of conventional pesticides, integrated pest management approaches can be implied which not only control the pests but also reduce the amount of pesticides used. It is an economical as well as ecologically sustainable and applicable method to get rid of pests (Oerke 2006).
- Diversified landscapes hold more potential for conservation of biodiversity and sustaining of pest control function (Bianchi et al. 2006).
- Integrated pest management has an objective to manage the population of pests below the economic threshold so that they are unable to destroy crop yield. Intercropping and trap cropping techniques are considered to be very favorable for maintaining natural arthropod populations and eradicating pest populations (Deguine et al. 2008).
- Excessive use of agrochemicals in conventional farming and crop management methods resulted in S.R. Imadi et al. 107 serious health and environmental concerns. It is a major factor behind the loss of biodiversity. Plants which are grown under nutrient-rich soil are more prone to pests and insects as compared to plants that are grown in nutrient-deficient soils. Methods of crop rotation can be applied in order to get rid of pests and insects. During crop rotation, plants which are less susceptible to that particular pest should be

grown which will increase the natural mortality rates of pesticides and decrease the overall population (Ghorbani et al. 2008).

- Push-pull strategies can be used to manage excessive pests in an integrated manner. These strategies include manipulation of behavior of insect pests and their natural enemies. The strategies use a stimulus that acts to be unattractive for pests (push) and a stimulus which is attractive to pests so that pests attract towards that stimuli (pull) from where they are removed (Cook et al. 2007).
- 2.2 Biodiversity and Living Soil Biodiversity is a fundamental principle for proper functioning of the food web (Savary et al. 2012). It is expected from living soil resources to increase the production of crops, produce large quantities of ligno-cellulosic biomass, enhance biodiversity, and improve the environment and carbon sequestration, developing the system which has a low risk for pollution and contamination and preservation of species (Lal 2008).
- Soil acidification is a natural process which is further enhanced by conventional farming methods. Acidity is attributed to growth-limiting factors for plants by complex interactions which include physical, chemical, and biological properties of soil. Calcium, phosphorus, and magnesium are deficient in acidic soil (Fageria and Baligar 2008).
- Agricultural biodiversity is a valued source which can be used to increase productivity of crops. It is due to agricultural biodiversity that plants can cope up with changes in climate and environment.
- Sustainable and secured food production is attributed to agricultural biodiversity (Frison et al. 2011). Most of the healthy plants which are propagated in the natural environment are colonized by communities of endophytic bacteria.
- This is a cause of large level of biodiversity associated with agriculture. The bacteria form a nonpathogenic relationship with plants which can be beneficial, detrimental, or neutral. These bacteria provide nitrogen in nonleguminous plants, which plays a role in reduction of requirement of nitrogen fertilizers.
- Certain plants favor association with growthpromoting bacterial endophytic population. It results in maintenance of fertile and disease-suppressive soil.
- This provides a sustainable system for growth of plants and enhancement of biodiversity (Sturz et al. 2000).

- One of the best techniques which can be applied for sustainability of soil is conservation agriculture.
- Conservation agriculture is a term which is defined as minimal soil disturbance and permanent soil cover through mulch which is combined with crop rotations. It is observed that this technique not only improves agriculture through water infiltration and reduction in erosion, but also improves soil surface aggregates and reduces compactness of soil. Conservation agriculture also promotes biological tilling approaches, levels of surface soil organic matter, and carbon content.
- It is also observed to be associated with a decrease in quantity of weeds (Hobbs 2007).
- Fertility of Soil and Fertilizers Soil infertility is the major constraint which limits the yield of crop worldwide.
- Maintenance of the quality of soil can also reduce many problems like degradation of land. Major components of soil are minerals, organic matter, and microorganisms. Physical, chemical, and biological properties of soil largely depend on these three components. Bio-fertilizers are a natural and sustainable way to enhance fertility of soil. These fertilizers are composed of cells of different types of beneficial microorganisms. These fertilizers act as a source of nitrogen, potassium, and phosphorus.
- They not only increase productivity of soil, but also enhance its sustainability. Low input and low cost are required to add bio-fertilizers in soil which can result in high output and enhanced yield of crops (Mohammadi and Sohrabi 2012).
- Negative effects of depletion of soil fertility on food security are of immense economic importance. These effects are further enhanced due to changes in climatic conditions and rise in prices of global fertilizers. For this purpose, efforts are being made to develop options of gaining soil fertility without harmful effects.
- Nitrogenfixing plants and fertilizer trees can act as the best option in this regard. It is observed that fertilizer trees add large amounts of nitrogen in soil through biological nitrogen fixation.
- The nutrients which contribute to soil by fertilizer tree biomass reduce the requirement of mineral nitrogen fertilizer to as low as 75 %. These trees also enhance the growth and yield of crops. Besides all these advantages, fertilizer trees are also observed to be profi

table and economical (Akinnifesi et al. 2011). For sustainable production of crops like wheat, maintenance of nitrogen levels in soil is very important.

- For this purpose, crop rotation approach is applied in which wheat plants were rotated with mung beans. It was observed that during the period of growth of mung beans, the concentration of nitrogen in soil was increased which was utilized by wheat during its growth.
- Application of organic fertilizers further increased the quantity of nitrogen in soil. Soils which are low in nitrogen can be treated with crop rotation technique to enhance nitrogen concentrations in a sustainable system (Bakht et al. 2009).
- Organic waste is considered to be organic treasure because it can be recycled into organic fertilizers through composting. One extra benefit of organic waste is that it can be used to produce biogas.
- Crop rotation with legumes is a significant method to enhance nutrient efficiency of soil (Yang 2006). In time and space, nitrogen supply should match the demands of nitrogen. This rule should not only be implied on single crop plants, but also for rotating crops as an integrated system.
- This will lead to higher agronomic nitrogen use efficiency (Spiertz 2010). Efficient management practices can lower the use of nutrients (Tilman et al. 2011).
- 3 Methods of Sustainable Agriculture Conventional system of agriculture can lead to degradation of the environment, economic problems, as well as social conflicts.
- Amount of organic matter in soil usually depends on input of organic material.
- Concentration of organic matter in the S.R. Imadi et al. 109 soil makes it living. If the decomposition rate of organic matter is low and input of materials is high, then the organic matter is high in soil. For cropping systems, equilibrium levels of organic matter of clay soil will be higher as compared to sandy soil (Johnston et al. 2009).
- Conventional pesticides are heavily used in conventional and industrial agriculture approaches. These pesticides are observed to be linked with endocrinal disorders as well as different types of cancers (Horrigan et al. 2002).
- Methods of crop rotation can be applied in order to get rid of pests and insects. During crop rotation, plants which are less susceptible to that particular pest should be grown which will increase the natural mortality rates of pesticides and decrease the overall

population (Ghorbani et al. 2008). Push-pull strategies can be used to manage excessive pests in an integrated manner. These strategies include manipulation of behavior of insect pests and their natural enemies.

- The strategies use stimuli that act being unattractive for pests (push) and stimuli which are attractive to pests so that pests attract towards that stimuli (pull) from where they are removed (Cook et al. 2007). It is very essential to study interactions of plants with arbuscular mycorrhizal fungi and other organisms for development of sustainable agriculture systems (Johannson et al. 2004).
- Conservation agriculture is considered to be the most sustainable agriculture production system for the future. In the next decade, agriculture is required to produce more food through less land and low resources with more efficient usage of nutrients and approaches.
- This will have a minimal impact on the environment and will also meet the demands of the ever-growing populations (Hobbs et al. 2008).
- Various plant species which are cultivated are found to be agents of bioremediation. These plants are involved in the sustainable reclamation of calcareous as well as saline sodic soils. These plants can be grown in saline and saline sodic soils to remove excess chemicals and to make these soils reasonable for the growth of different plant species. This is an eco-friendly as well as environmentally sustainable technique (Qadir and Oster 2004).
- Intercropping is a technique which is one of the oldest to be used in agriculture. It is a sustainable technique in which multiple crops are planted in a sequence which not only protect the plants from diseases and pests but also help in reducing environmental degradation.
- This technique uses available growth resources and produces a high yield of mixture of crops. It also improves the fertility of soil by biological nitrogen fixation (Lithourgidis et al. 2011).

Organic Farming: A Sustainable Approach

The desire for sustainable agriculture system is universal (Rigby and Cáceres 2001). Organic farming is a sustainable farming system and is considered to be a potent solution for loss of biodiversity and degradation of the environment (Hole et al. 2005). Organic farming is observed to offer a number of characteristics that increase resilience in plants (Milestad and Darnhofer 2003). Symbiotic relationships with mycorrhizal fungi and leguminous bacteria act as a support in an organic farming Sustainable Crop Production System. In this phenomenon, the fungi or bacteria penetrate into the roots of plants and benefit them with an increase in yield and quality of crops. It is due to symbiotic relationships that nutrition of the soil is enhanced and soil structure gets improved. Pest and disease control is also one of the aspects of symbiotic relationships during organic farming (Gosling et al. 2006).

Organic farming is perceived to be more environmentally friendly as compared to conventional farming techniques. Most of the consumers nowadays are attracted towards organic food because this food is without any chemicals (Darnhofer et al. 2010).

Organic farming is associated with an increase in richness of species in soil. It is observed that the species biodiversity in organic farms is 30 % more than that in conventional farms. Birds, insects, and plants are usually healthier in organic farming.

The yield of the crops is enhanced. On an average living beings are 50 % more in organic farming which leads to the development of sustainable systems (Bengtsson et al. 2005). It is also observed that organic farming of crops is associated with an increase in the richness of butterfly species (Rundlöf and Smith 2006).

It has a positive impact on the environment; hence, it is expected that conversion to organic farming will lead a way to overcome shortcomings of current conventional methods of agriculture (Darnhofer 2005).

Organic farming has a greater impact for long-term sustainability. It is also observed that organic farming emits a low number of greenhouse gases. Organic farming is a technique which can reduce total water, energy, and greenhouse gases involved in food production (Wood et al. 2006). In an experiment in which organic farming and conventional farming were compared on 293

examples, it was observed that organic farming has a potential to contribute substantially to global food supply as well as it reduces detrimental impacts on the environment (Badgley et al. 2007).

Low input sustainable agriculture (LISA)

Intensive usage of chemical pesticides and fertilizers has caused serious environmental problems (George, 2009). The negative effects on human health, agro ecosystems (e.g., killing beneficial insects), wider environment (e.g., non-target species, landscapes and communities), and polluting water and groundwater resources are some examples of unsustainable consequences of insecticide use. (Devine and Furlong, 2007; Pimental and Paoletti, 2009). Several studies show a rapid growth of chemical pesticides and fertilizers usage in Iran. E.g. Mohammadi (2010) reported that about 50% chemical fertilizers usage is not necessary in Iran. It is estimated that pests damage 42 percent of agricultural products in Iran (Asgari, 2009). The estimated amount of different agrochemical pesticides (insecticides, nematicides, fungicides, and herbicides) used in Iran is 17-25 million liters a year, which is more than the optimum requirement (Molazadeh, 2010).

Experts in response to the adverse environmental and economic impacts of high chemical usages have proposed the adoption of low input sustainable agriculture (LISA). U.S congress (1990) defined sustainable agriculture as following. It is an integrated system of plant and animal production practices having a site-specific application that will, over the long term, satisfy human food and fiber needs; enhance environmental quality and natural resources base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm ranch resources and integrated, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole.

Pretty (1996) identifies a number of goals of sustainable agriculture, which include: (1) a more thorough incorporation of natural processes. (2) A reduction in the use of off-farm, external and nonrenewable resources. (3) More equitable access to resources. (4) Greater productive use of local knowledge and practices. (5) Greater self-reliance for farmers and rural populations. (6) A better match between production practices and climate and landscape. (7) Profitable and efficient

production with an emphasis on conservation of the soil, water, energy and biological resources. Low Input Agricultural farming systems seek to optimize the management and use of internal production inputs (i.e., on farm resources) and to minimize the use of external production inputs, such as purchased fertilizer and pesticides, wherever and whenever feasible and practical, to lower production costs, to avoid pollution of surface and ground water, to reduce pesticide residues in food, to reduce a farmers overall risk, and to increase both shortand long-term farm profitability (Parr et al., 1990).

Reijntjes et al. (1992) define Low External Input Sustainable Agriculture (LEISA) as “agriculture which makes optimal use of locally available natural and human resources (such as soil, water, vegetation, local plants and animals, and human labor, knowledge and skills) and which is economically feasible, ecologically sound, culturally adapted and socially just. The use of external inputs is not excluded but is seen as complementary to the use of local resources and has to meet the above mentioned criteria”.

Schaller (1993) notes that adoption of the term “low input” had an effect rather different from that originally intended. The term was chosen to try to correct the view held by some agricultural groups that sustainable agriculture was just another name for chemical-free or organic farming.