Agron 511- Cropping System and Sustainable Agriculture (2+0)

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Concept Of Cropping System & Farming System, Scope, Objective,Production Potential Under Monocropping, Double Cropping, Multiple Cropping, Alley Cropping, Sequence Cropping & Intercropping, Mechanism of Yield Advantage in Intercropping

Concept of sustainable agriculture

- The concept of sustainable agriculture means protecting the natural resources needed for human food-grain production and cooking fuels, while expanding production to meet the needs of growing population.
- In other words, sustainable development means more efficient use of arable lands and water supply as well as development and adoption of improved agricultural practices and technologies to increase crop yields.
- **Sustainable agriculture** : It can be defined as that form of agriculture aimed at meeting the food and fuel needs of the present generation without endangering the resource base for the future generations. It is an efficient management system of renewable resources including soil, forests, crops, biodiversity and ecosystem without degradation, to provide adequate food and other needs for the current and future generations.

Components of sustainable system

1. Soil and water conservation to prevent degradation of soil productivity and lengthening of crop growing season in dry-land agriculture.

2. Efficient use of limited irrigation water to avoids problems of soil salinity, alkalinity and high groundwater table.
3. Appropriate crop rotations to mitigate weed, disease and insect problems besides soil productivity improvement.
4. Integrated nutrient management that reduces the need for inorganic fertilizers, improves the soil health and minimize the environmental pollution by conjunctive use of organics, in-organics and bio-fertilizers.
5. Integrated plant protection that reduces the need for agrochemicals through crop rotation, weather monitoring, use of resistant varieties, timely planting of crops and biological plant protection.
6. Management systems to control weeds by preventive measures, tillage, timely cultivation and crop rotation which improve plant health.

Concept of sustainability in cropping and farming system

Sustainability is defined as the production system aimed at achieving maximum production while maintaining the resources base for the future generation.

The concept of sustainable agriculture is a relatively recent response to the decline in the quality of the natural resource base associated with modern agriculture

It has promoted the :

1. Need to propose major adjustments in conventional agriculture
2. To make it more environmentally, socially and economically viable and compatible.
3. The main focus lies on the reduction or limitation of agrochemical inputs through changes in management to assure adequate plant nutrition and plant protection through organic nutrient sources and integrated pest management, respectively.

Scope of Cropping System

1. Optimizing the use of locally available resources by combining the different components of the farm system, so that they complement each other and have the greatest possible synergetic effects.

2. Reducing the use of off-farm, external and non-renewable inputs with the greatest potential to damage the environment or harm the health of farmers and consumers, and a more targeted use of the remaining inputs used with a view to minimizing variable costs.
3. Relying mainly on resources within the agro-ecosystem by replacing external inputs with nutrient cycling, better conservation, and an expanded use of local resources.
4. Improving the match between cropping patterns and the productive potential and environmental constraints of climate and landscape to ensure long-term sustainability of current production levels.
5. Working to value and conserve biological diversity, both in the wild and in domesticated landscapes, and making optimal use of the biological and genetic potential of plant and animal species.
6. Taking full advantage of local knowledge and practices, including innovative approaches not yet fully understood by scientists although widely adopted by farmers.

Objective of cropping system

- ✓ Help to sustain agricultural production by having healthy rural communities, conserving natural resources, and remaining economically competitive.
- ✓ Identify methods of reducing off-farm input expenses, particularly irrigation, herbicides, and nitrogen fertilizer.
- ✓ Develop cropping systems that implement integrated pest management (IPM) practices for prolonging the useful life of selective herbicides, and reducing the amount and expense of pesticide applications.
- ✓ Designing crop rotations that maximize precipitation (PUE) and fallow (FUE) use efficiency.

Scope of Farming System

Farming enterprises include crop, livestock, poultry, fish, free, sericulture etc. A combination of one or more enterprises with cropping when carefully chosen planned and executed gives greater dividends than a single enterprise, especially for small and marginal farmers. Farm as a unit is to be considered and planned for effective integration of the enterprises to be combined with crop production activity.

Objectives of Farming System :

1. To identify existing cropping and farming systems in specific areas and access their relative viability.
2. To formulate cropping and farming system model 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.
4. To maintain sustainable production system without damaging resources/environment.
5. To rise over all profitability of farmhouse hold by complementing main/allied enterprises with other.

Production potential under mono cropping :

1. Government agricultural subsidies tend to favor mono-cropping.
2. Cultivating only a single species, can stress the fertile topsoil and reduce genetic diversity.
3. This has increased in both farm size and dependency on technology.
4. Intensive farming systems lend themselves to greater waste production and greenhouse gas emissions.
5. It increases the susceptibility of plants to disease as a single pathogen has the potential to destroy an entire crop.
6. It also contribute to the proliferation of crop pests and diseases, which can be a serious liability when a farmer's land is planted exclusively with one crop.
7. It also generally reduces crop diversity, which is perceived as a bad thing both because the loss of biodiversity is unfortunate, and because if a crop does become subject to a particular pest or disease, a lack of biodiversity makes it especially vulnerable.
8. Many large agricultural companies engage in mono cropping, planting only one strain of one crop, which is very harmful for diversity and for the crop.
9. It allows a farmer to specialize in a particular crop, which means that he or she can invest in machinery designed specifically for that crop along with high-yield seeds which will generate a large volume of the crop at harvest.

10. It severely depletes the soil, as the plant will strip the soil of the nutrients it needs. This forces farmers to use fertilizers, which can disturb the natural balance of the soil and contribute to a host of environmental problems, from pollution to desertification.
11. It can also contribute to the proliferation of crop pests and diseases, which can be a serious liability when a farmer's land is planted exclusively with one crop.

Production potential in multiple cropping

1. Multiple cropping is the growing of two or more crops on the same field during the same year.
2. Its potential are to utilize the soil more efficiently, resulting in greater production from a given unit of land.
3. Double, triple, and even quadruple cropping has dramatically increased food production in somecountries–making them exporters instead of importers of food crops.
4. Both high and low technology societies can profit from greater use of multiple cropping.

Alley Cropping :

Alley cropping is broadly defined as the planting of two or more sets of single or multiple rows of trees or shrubs at wide spacing, creating alleyways within which agricultural, horticultural, or forage crops are cultivated. The trees may include valuable hardwood species,, such as nut trees, or trees desirable for wood products. This approaches sometimes called intercropping and multiple cropping.

Benefits of Alley Cropping

- Diversify farm enterprise
- Reduce erosion
- Improve water quality
- Protect crops
- Enhance wildlife
- Improve aesthetics

Diversifying farm products and supplementing income

Alley cropping diversifies farm enterprises by providing short-term cash flow from annual crops while also providing medium to long-term products from the trees.

Timber and non-timber products may contribute to income generation from the farm. In addition to the potential for producing nuts, berries, and fruits, well-managed timber can provide a long term investment.

Reducing soil erosion from wind and water :

Soils with a high erodability index (>8) are highly susceptible to damage and are difficult to protect when used as crop land.

The soil erodability index provides a numerical expression of the potential for a soil to erode considering the physical and chemical properties of the soil and the climatic conditions where it is located.

The higher the index, the greater the investment needed to maintain the sustainability of the soil resource base if intensively cropped.

Reducing erosion :

Trees and shrubs improve crop production by slowing wind speed and reducing wind erosion, modifying the crop microclimate with similar effects to that of windbreaks.

1. Alley cropping can reduce crop evapotranspiration by 15-30 percent and increase water content in the tillage layer by 5-15 percent.
2. Deep tree roots transport soil nutrients to leaves. Leaves contribute organic matter to soil and release nutrients as they decompose.

Protecting crops :

Alley cropping protects crops from insect pests by reducing crop visibility, diluting pest hosts due to plant diversity, interfering with pest movement, and creating environments less favorable to pests and more favorable to beneficial insects.

Enhancing wildlife habitat and aesthetics:

Linear plantings of trees and/or shrubs in an agricultural landscape increases the habitat diversity for wildlife, both through increased amount of edge and/or as a result of the increased diversity(vertical and horizontal) of vegetative types.

Limitations to Alley Cropping:

1. Alley cropping, as with other forms of multi-cropping, requires more intensive technical management skill and marketing knowledge.
2. The following limitations should be considered:
3. Requires a more intensive management system including specialized equipment for tree management and additional managerial skills and training to manage multiple crops on a given site.
4. Removes land from annual crop production and may not provide a financial return from the trees for several years.
5. Require smartening infrastructure for the tree products that may not be present in the local area. Trees may be an obstacle to crop cultivation if not carefully planned and designed.
6. Trees compete with companion crops for sun, moisture and nutrients.
7. Companion crops may compete with trees for moisture and nutrients.
8. Herbicide drift from crops may damage trees.

Inter cropping :

Intercropping requires only 60-80 percent of the land to equal the production of mono cropping systems.

1. Intercropping can take any of three forms–strip planting, row planting, or mixed planting. The form chosen should be based on crops grown and such factors as ease of planting, weeding, and harvesting. Yield also may be affected.

2. Crops of different maturities have varying peak requirements for water, fertilizer, light, and space. Thus, there may be less competition between different crops than there is in a sole planting of identical plants.

3. 4. Moreover, disease and insect infestation of intercropped plants tends to be less. For example, virus diseases may spread more easily through adjacent plants than to those separated by unlike, and frequently non-susceptible, neighboring plants.

4. 5. Insects that' spread disease are also thwarted or at least slowed. Insects tend to be less attracted to plants that are intermingled with other species than to those in solid stands of the same species.

Intercropping is the cultivation of two or more crops simultaneously on the same field. It also means the growing of two or more crops on the same field with a definite row arrangement.

Intercropping is defined as “the growth of more than one crop species or cultivar simultaneously in the same field during a growing season”.

It is the practical application of ecological principles such as diversity, crop interaction and other natural regulation mechanisms.

Intercropping help to

1. systemIncrease yield
2. Better nutrient recycling in the soil
3. Better control of weeds, pests and diseases
4. Increased biodiversity.
5. In legume–cereal intercrop the input of nitrogen to the system by the fixation of atmospheric N_2 by the legume, which results in improved use of renewable nitrogen sources.
6. Increase the biodiversity of the farming

Types of intercropping practices :

Strip Intercropping: Growing two or more crops in strips, wide enough to permit independent cultivation, but narrow enough for the crops to interact.

Row Intercropping: Growing two or more crops in well-defined row.

Mixed Intercropping: Growing two or more crops together in no distinct row arrangement.

Relay Intercropping: Planting a second crop into a standing crop at a time when the standing crop is at its reproductive stage but before harvesting.

Advantages of intercropping :

1. **Biodiversity and stability**: Intercropping is a way to increase the biodiversity of the farming system. More diversity in the farming system means more stability, resulting in risk spreading and reduced pest and disease incidence.
2. **Increased yield** : When two or more crops with different rooting system, a different pattern of water and nutrient demand, and a different above ground habit are planted together. Water, nutrient and sunlight are used more efficiently. Therefore the combined yields of two crops grown as intercrops can be higher than the yield of the same crop grown as pure stand.
3. **Maintenance of soil fertility** :When a cereal crop or a tuber crop is grown in association with pulses . Deep rooted pulses like pigeon pea, also take up nutrients from deeper soil layer, there by recycle nutrients leased from the surface. Legumes also grow well in low phosphate. After the intercrop is harvested, decaying roots and fallen leaves provide nitrogen and other nutrient for the next crop.
4. Fodder and manure: The crop residue of the pulses crop can also be used as fodder, by cutting and carrying them to the animal, or by letting the animals graze the residues in the field. The nutrients manure is used to fertilize the crops. Animal manure improves soil fertility through supply of nutrients and soil structure, as it increases the amount of humus in the soil. It should be sprayed evenly over the field, whether the manure is left on the field during grazing or collected from the stable and applied later
5. Soil cover: Pulses in an intercropping system not only provide a source of nitrogen and other nutrients to the associated crop but, also increase the amount of humus in the soil, due to decaying crop remains.
    - This result in improved soil structure
    - Reducing the need for soil tillage.
    - Reduce water losses
    - Decrease soil erosion
    - Reduce leaching of nutrients
    - Improved soil structure and better soil cover, especially when creeping pulses crops are used.
    - With a good soil cover, the impact of rain drops on disruption of the soil is reduced.

6. Risk spreading and food security: When two or more crops are grown on the same field, the risk for crop failure is spread over the different crop as the different crops have different periods and patterns of growth, and are affected by different diseases. Increases food security.
7. Weed control: In an intercropping system weeds are more easily controlled. For example in maize bean intercrop, the bean covers the soil, preventing weeds to grow.
8. Microclimate: When the intercrop provides a good soil cover, soil temperature will stay relatively low. This prevents burning of the organic matter in the soil and loss of nutrients. It also provides a microclimate that can be favorable for the associated crop.
9. Physical support: In a maize bean intercrop, climbing beans can use the maize stacks for support.
10. Pest and diseases control :

    Pest and diseases are less abundant in intercropping system. If the pest or disease has a specific host, it does not spread as easily through an intercrop as it does in a mono crop. Insect or other pest can also be misled by the canopy of an intercrop and not recognize the specific crop they use as host.that other crops produce may drive insects away from the main crop or natural enemies of insects may be attracted by one of the crops in the intercrop.

Need of intercropping :

1. Provides increased protection against erosion
2. Insures against crop failure
3. Spreads labour and harvesting more evenly during the growing season and helps to minimize storage problems.
4. Helps to allocate space for crops required in small quantities, and facilitates production of many commodities in a limited area
5. In efficient use of resources by plants of different heights, rooting systems, and nutrient requirements

6. When legumes are grown with grasses (or other non-legumes), grasses may benefit from the nitrogen fixed by the legume companion crop.
7. Inhibits the spread of diseases and pests since not all crops involved are susceptible to the same extent to the same problems.

Disadvantages :

1. Mechanized planting and harvesting are difficult
2. It is more difficult to apply needed fertilizers and other chemicals as in sole cropping
3. Experimentation with intercropping is more complex and difficult to manage than with sole cropping.

Mechanism of yield advantages in intercropping system:

Since several crops are involved in intercropping system, it is not logical to compare total yield of different crop in on system with the other.

Crop equivalent yield (CEY):

The yields of different intercrops are converted into equivalent yield of anyone crop based on price of the produce. The crop equivalent yield (CEY) is calculated as follows-

CEY = (Yi. ei)

Where,

Yi is the yield of ith component

ei is the equivalent factor of ith component or price of ith crop.

Land equivalent ratio (LER):

Land equivalent ratio (LER) is the relative land area under sole crops that is required to produce the yields achieved in intercropping.

LER = Yi / Yij

Where,

Yi is the yield of ith component crop from a unit area grown as intercrop

Yij is the yield of ith component grown as sole crop over the same area

LER is the summation of ratios of yields of intercrop to the yield of sole crop

Relative yield total (RYT) :

In pasture, different species of plants are grown for grazing in different proportion. The yields of these crops are higher when they are grown as sole crops with100 percent population compared to their yield in pastures with reduced population.

To accommodate more number of crops in pasture, certain amount of population of intercrops are reduced It is necessary to know which crop combination gives higher forage yield.

The yield advantage is, therefore, measured not only based on unit area, but also based on unit population which is estimated by relative yield total. This is mainly used for replacement series of experiments.

Relative yield total (RYT) :

RYT = (Yab +Yba) / (Yaa+Ybb)

Where,

Yaa = Yield of component “a” as sole crop

Ybb= Yield of component “b” as sole crop

Yab = Yield of component “a” as inter crop in “b”

Yba= Yield of component “b” as inter crop in “a”

Relative crowing coefficient (RCC) :

This was proposed by DeWit (1960) and is used in replacement series experiment. Each component has its own coefficient (K) which gives a measure of whether that component has produced more, or less yield than expected.

Rab= Mixture yield of “a” / (Pure stand yield of “a”- mixture yield of “a”)

Rab= Yab×Zab / (Yaa- Yab)×Zab

Where,

Z a b =proportion of component “a” in combination with “b”

Z a b =proportion of component “b” in combination with “a”

Relative crowing coefficient (RCC) :

To determine the yield advantage of mixing, the product of the coefficient is formed. This is termed K.

For,

K>1=Yield advantage

K=1=Yield advantage

K<1=Yield disadvantage