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

- Cropping system, definition, indices and its importance
- Physical resources
- Soil and water management in cropping system
- Assessment of land use

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Cropping Systems

What is System: A system is a group of interacting components, operating together for a common purpose, capable of reacting as a whole to external stimuli.The term cropping system refers to the crops, crop sequences and the management techniques used on a particular field over a period of years.

Cropping system is an important component of a farming system. It represents cropping pattern used on a farm and their interaction with farm resources, other farm enterprises and available technology which determine their make up.Pattern of crops taken up for a given piece of land, or sequence in which the crops are cultivated on piece of land over a fixed period and their interaction with farm resources and other farm enterprises.

Copping pattern: means the proportion of area under various crops at a point of time in a unit area. It indicates the yearly sequence and spatial arrangement of crops and fallow in an area.

Cropping scheme : is a plan according to which crops are grown on individual plot of a farm during a given period of time with the object of obtaining maximum return from each crop without impairing soil fertility. Thus a cropping scheme is related to the most profitable use of resources, land, labour, capital, and management.

Types of Cropping System

Mono cropping :

Mono cropping refers to growing of only one crop on a piece of land year after year. E.g. under rainfed conditions sorghum is grown year after year.

Multiple cropping :

Growing two or more crops on the same piece of land in one calendar year is known as multiple cropping. It is intensification of cropping in space and time dimensions. It includes intercropping, mixed cropping and sequence cropping.

Double cropping : Growing of two crops in a year in sequence.

Triple cropping : Growing of three crops in a year in sequence.

Quadruple cropping : Growing of four crops in a year in sequence.

Intercropping:

Intercropping is growing two or more crops simultaneously on the same piece of land with a definite row pattern. For example growing maize + green gram in 2:1 ratio.

Mixed cropping: is growing two or more crops simultaneously intermingled without any row pattern. It is common practice in most of dry land areas.Sequence cropping : growing of two or more crops in sequence on the same piece of land in a farming year.

Parallel cropping: Cultivation of such crops which have different natural habit and zero competition. e.g. Black gram /green gram + maize. The peak nutrient demand period for green gram is around 30-35 DAS while it is 50 DAS for maize.

Multi-storied/multi-tiered cropping/multi-level: Cultivation of two or more than two crops of different heights simultaneously on a certain piece of land in a certain period. For Example sugarcane + mustard + onion.

Alley cropping/ Hedgerow intercropping :

Agro forestry, farm forestry and family forestry can be broadly understood as the commitment of farmers, alone or in partnerships, towards the establishment and management of forests on their land. Where many landholders are involved the result is a diversity of activity that reflects the diversity of aspirations and interests within the community. Alley cropping, sometimes referred to as 'sun systems', is a form of intercropping.

Advantages of alley cropping

- Higher productivity per unit area per unit time
- Efficient and better use of natural resources–land, light and water and applied resources–labourers, manures, fertilizers, crops and varieties.
- Best management practices (BMP)
- Providing physical support to other crops e.g. Lablab on sorghum.
- Providing wind shelter and shade to the component crops. For example, Oak for tea or Albizzia for Tea or castor or red gram for turmeric.

Indices in Cropping System

1. Relative Crowding Coefficient
2. Aggressivity
3. Competition Index
4. Competition Coefficient
5. Cropping Intensity

6. Multiple Cropping Index
7. Cropping Intensity Index
8. Specific Cropping Intensity Index
9. Diversity Index
10. Harvest Diversity Index
11. Simultaneous Cropping Intensity

1. Land Equivalent Ratio:

It denotes relative land area under sole crop required to produce the same yield as obtained under a mixed or an intercropping system at the same level of management. It is the ratio of land required by pure crop to produce the same yield as intercrop.

LER = Ya/Sa + Yb/Sb

Where,

Ya, Yb is the yield of a and b crop grown as intercrop,

Sa, Sb is the yield of a and b crop grown as sole crop,

LER = Yield of intercrop over yield of pure crop.

2. Relative Crowding Coefficient (RCC):

It is used in replacement series of intercropping .It indicates whether a crop, when grown in mixed population, has produced more or less yield than expected.

K a b = Y ab / Y aa Y ab X Zba/Zab

Where,

Kab=RCC of crop a intercropped with crop b,

Yab=Yield per unit area of crop a intercropped with crop b,

Yaa= Yield per unit of sole crop a

Zab=Proportion of intercropped area initially allocated to crop, a

Zba=Proportion of intercropped area initially allocated to crop, b

RCC > 1 means yield advantage

RCC = 1 no difference

RCC < 1 yield disadvantage

3. Aggressivity

It is the mixture of how much the relative yield increase in component a is greater than that for b.

Aab = Yab / (Yaa x Zab) - Yba/(Ybb x Zba)
Where,
Aab = Zero mean component crops are equally competitive
Aab = negative means dominated
Aab = Bigger value either positive or negative means bigger difference in competitive abilities.

4. Competition Index:

It is measure to find out the yield of various crops when grown together as well as separately. It represents the yield per plant of different crops in mixture and their respective pure stand on unit area basis.

CI = (Yaa -Yab) X (Ybb -Yba) / Yaa x Ybb

Yab- mixture yield of a crop grown with b
Yba- mixture yield of b crop grown with a
Yaa-yield in pure stand of crop a
Ybb-yield in pure stand of crop b

5.Competition coefficient:

Ratio of the RCC of any given spp. in the mixture

CC = RCC of a given spp. /Total RCC of all crops in mixture

6. Rotational Intensity:

This is calculated by counting the number of crops grown in a rotation and is multiplied by 100 and then divided by the duration of rotation.

7.Cropping intensity: Total cropped area over net cultivated area x 100

Or

Area *under kharif* + *rabi* + *zaid*over area under actual cultivation x 100

8. Land Use Efficiency or Assessesment of Land Use:

The main objective is to use available resources effectively.

Multiple cropping which include both inter and sequential cropping has the main objective of intensification of cropping with the available resources in a given environment.

9. Multiple Cropping Index or Multiple Cropping Intensity (MCI):

It is the ratio of total area cropped in a year to the land area available for cultivation and expressed in %.

$$MCI = \frac{a1}{A} * 100$$

Where
i = 1, 2, 3, n, n= total number of crops,
a1 = area occupied by crop and
A= total land area available for cultivation.

MCI is the sum of area planted to different crops and harvested in a single year divided by total cultivable area and expressed as percentage.

OR

MCI means the sum of areas under various crops raised in a single years divided by net area available for that cropping pattern multiplied by 100. It is similar to cropping intensity.

$$\textbf{MCI} = \frac{\textbf{Total number of crops + with their respective area}}{\textbf{Net cultivable area}} * 100$$

10. 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.

$$\textbf{CLUI} = \frac{\textbf{ai di}}{\textbf{A x 365}} \textbf{ x } \textbf{100}$$

Where,
Ai = area occupied by the ith crop
di = days that the ith crop occupied
A = total cultivated land area available for 365 days.

11. Crop Intensity Index (CII):

Crop intensity index assesses farmers actual land use in area and time relationship for each crop or group of crops compared to the total available land area and time, including land that is temporarily available for cultivation.

$$\mathbf{CII} = \frac{\mathbf{ai\ .ti}}{\mathbf{AOT + AjTj}}$$

Where,

i = 1, 2, 3……n,

NC = total number of crops grown by a farmer during the time period (T)

ai = area occupied by ith crop

T = time period under study (usually one year),

AO = Total cultivated land area available with the farmer for use during the entire time period, (T)

Aj = land area of jth field

Tj = time period Aj is available.

CII indicates the number of times a field is grown with crops in a year. It is calculated by dividing gross cropped area with net area available in the farm, region or country multiplied by 100.

$$\mathbf{CII} = \frac{\mathbf{Gross\ cropped\ area}}{\mathbf{Net\ area}} \times \mathbf{100}$$

When long duration crop grown crop remain longer time in field this is the drawback of CII.

So time is not considered, thus , when long duration crops like sugarcane and cotton are in grown, the cropping intensity will be low, though crop remain longer period of time in the field.

12. Specific Crop Intensity index:

SCII is a derivative of CII and determines the amount of area time denoted to each crop or group of crops compared to total available to the farmers. It was proposed by Menegay et al. 1978

$$\mathbf{SCII} = \frac{\mathbf{ak.tk}}{\mathbf{AOT + a1\ t1}}$$

Where N k = total number of crops such as vegetable crops or field crops grown by the farmer during the time period T

A k = area occupied by the k th crop.

t k = duration of kith crop.

Using this formula vegetable intensity index, rice intensity index, field crops intensity index etc. can be calculated.

13.Diversity Index (DI):

It measures the multiplicity of crops or farm products which are planted in a single year by computing reciprocal sum of squares of the share of gross revenue received from each individual farm enterprises in a single year.

It was suggested by Strought (1975) and Wang and Yu (1975).

$$\mathbf{DI} = \frac{\mathbf{1/yi}}{\mathbf{yi}}$$

Where,
N = total number of enterprises (crops or farm products) and
yi = gross revenue of ith enterprises produced within a year.

14. Harvest Diversity Index (HDI):

It is computed using the same equation as the DI expects that the value of each farm enterprises is replaced by the value of each harvest.

$$\mathbf{HDI} = \frac{\mathbf{1/Yi}}{\mathbf{Yi}}$$

Where,
Yi = gross value of ith crop planted and harvested within a year.

15. Simultaneous Cropping Index (SCI):

It is computed by multiplying the HDI with 10,000 and dividing the product by MCI. (Strout, 1975).

$$\mathbf{SCI} = \frac{\mathbf{HDI \times 10,000}}{\mathbf{MCI}}$$

16. Relative Cropping Intensity Index (RCII):

It is the ratio of the amount of area and time allotted to 1 crop or groups of crop related to area-time actually used in the production of all crops.

$$\mathbf{RCII} = \frac{\mathbf{ak.tk}}{\mathbf{ai\ .\ Ti}}$$

It is used for classifying (i.e a farmer with relative vegetable intensity index 50% would be considered a vegetable grower.) measuring shifts of various crops among farm of different sizes and determining whether the consistent types of cropping pattern occur within various farm size strata.

17. Crop Equivalent Yield (CEY):

The yields of different intercrops are converted into equivalent yield of any one crop based on price of the produce. In such situations, comparisons can be made based on economic returns (gross or net returns). The yield of protein and carbohydrate equivalent can also be calculated for valid comparison. Efforts have also been made to convert the yields of different crops into equivalent yield of any one crop such as wheat equivalent yield.

(Lal and Ray, 1976 and Verma and Modgel,1983). Verma and Modgel, (1983) evolved the equation for calculating wheat equivalent yield (WEY).

Physical Resources :

1.Farm resource : land, labour, capital and infrastructure
2.Farm enterprise : dairy, poultry, fish, pig, goat, sheep, ducks

3.Farm technology: machines and implements
4.Fertilizers application
5. Nutrient Supplementation Index
6. Solar Radiation

FertilizerApplication:

1. The amount of nutrients present in the component crops indicates the requirement of fertilizers for the intercropping system.
2. The nutrient uptake is generally more in cropping system compared to pure crops.
3. When legumes are associated with cereal crop in intercropping system, a portion of nitrogen requirement of cereal is supplemented by the legumes. The amount may be as small as a few kilograms to 20 kg/ha.
4. 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.
5. Cereal + legume intercropping, therefore, are mainly advantageous under low fertilizer application.
6. Nitrogen dose recommended for base crop as pure crop is sufficient for intercropping system with cereals + legume or legume + legume.
7. With regards to phosphorus and potassium, one-eighth-one-fourth of the recommended dose of intercrop is also added in addition to recommended dose of base crop to meet the extra demand.

Nutrient supplementation index (NSI):

Nutrient supplementation index has been proposed to adjust fertilizer requirement NSI express the per cent of usual uptake for a given nutrient by sole crop *A which should be* added to the intercrops to meet the combined requirement of crops *A and B.*

NSI (A) = 100 x Na + Nb/NA-1
Where,
NSI (A) = NAI of crop A for a given nutrient,
NA= nutrient uptake by sole crop A for the same land area (kg/ha),
Na= nutrient uptake of mixture A for the same land area as sole crops A , and

Nb= nutrient uptake of B in mixture for the same land area as sole crop B.

The NSI attempts to adjust total fertilizer input into cropping system, based on the relative uptake of each component crop as sole crop,

Solar Radiation :

1. The taller crop in the intercropping systems intercepts most of solar radiation while shorter component suffers.
2. Solar radiation is utilized efficiently by both crops. *In groundnut + red gram intercropping system, light interception is prolonged as red gram starts growing after the harvest of groundnut*.
3. If the component crops have different growth durations, the peak demand for light occurs at different times. *In maize + green gram intercropping system, green gram flowers in 35 days after sowing and is harvested 65 days after sowing*.
4. Peak light demand for maize occurs at 60 days after sowing when green gram is ready for harvest. In such intercrops, there is less competition among component crops and higher solar radiation is intercept in intercropping systems than in pure stands.
5. Basal dose of nitrogen is applied to rows of both components in cereals + legume intercrop system.
6. Top dressing of nitrogen is done only to cereal rows.
7. Phosphorus and potassium are applied as basal dose to both crops.

Benefits of cropping systems :

1. Maintain and enhance soil fertility: Some crops are soil exhausting while others help to restore soil fertility. However, a diversity of crops will maintain soil fertility and keep production level high.
2. Enhanced crop growth: Crops may provide mutual benefits to each other for. For example, reducing lodging, improving winter survival, or even acting as windbreaks to improve growth.
3. Minimize spread of disease: The more divers the species of plants and the longer period before the soil is reseeded with the same crop, the more likely disease problems will be avoided.
4. Control weeds: Crops planted at different times of the year have different weed species associated with them. Rotating crops helps prevent build up of any one serious weed species.
5. Inhibit pest and insect growth: Changing crops each year to unrelated species can dramatically reduce the population of pests and insects. Crop, crop rotation frequently eliminates their food source and changes the habitat available to them.
6. Increase soil cover. Growing a diversity of crops helps keep field sizes smaller, which increases soil cover, improves solar radiation capture and reduces erosion.
7. Use resources more efficiently. Having a diverse group of crops helps to more efficiently use the available resources, natural resources, such as nutrients, sunlight and water in the soil, are evenly shared by plants over the growing period, minimizing the risk for nutrient deficiencies and drought.

8. Reduce risk for crop failure : Having a diverse group of corps helps prevent total crops equally. It also reduces food security concerns, as well as the amount of money required to finance production.
9. Improved food and financial security: Choosing an appropriate and diverse number of crops will lead to a moue regular food production throughout the year. With a lower risk for crop failure, there is a greater reliability on feed production and income generation.

Soil and water management in cropping system include seed bed preparation ,sowing and tillage

Seed bed preparation :

I. 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.
II. Certain crops like cotton and maize are planted on ridges, while most of the other crops are grown on flat seedbed.
III. Since more than one crop is involved in intercropping, the seedbed preparation is generally done as per the needs of base crop.
IV. 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 + green 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 rain fed conditions.

Sowing:

1. Sowing of base crop is done either as paired row, paired-wider row or skip-row plating, the sowing of base crop and intercrop is also done in fixed ratio, in paired-row planting, two rows of base crop are brought close by reducing inter row spacing.
2. The spacing between the two pairs of rows are increased of accommodate the intercrop.
3. The seed drill used for normal planting contains tunes with uniform spacing. The spacing of the types on the beam of seed drill is to be changed to 20/40 or 30/60 as per requirement for sowing in paired rows.
4. Planting in fixed ratio of intercrops is most common. The intercropping system of groundnut + reed gram is either in 7:1 or 11:1 ratio and sorghum + red gram + 2:1 ratio.
5. For higher yields, base crop population is maintained at its sole crop population and intercrop population is kept at 80 per cent of its sole crop population.
6. 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.

Tillage:

Tillage increases conservation of soil moisture by making the soil more permeable to rain water.

i. Deep tillage (25 to 30 cm) breaks open hard soil layers for faster penetration of rain water.
ii. Off season or pre-monsoon tillage has marked impact on rain.
iii. Water intake and weed management. Improvement in yield due to off season tillage ranges from 150 to 250 kg/ha under different situations.

iv. Excessive tillage in light soil accelerates erosion besides creating unfavorable conditions for soil organic matter buildup.
v. In general, no tillage systems are not ideal under rain fed situation in India.

Water Management

There is close correlation between surface water flows and grain yield of maize of suggest that subsurface hard layers makes the subsurface water to move in different directions based on the hard pans or clay lens. The subsurface water path ways can be mapped with color infrared andwith ground penetrating radar. The method of increasing water use efficiency can be grouped into three:

(1) increasing the efficiency of water delivery and timing of water application

(2) increasing the water use efficiency of crop

(3) increasing drought tolerance of crop,

Water use efficiency

$$WUE = Y/ET$$

Where ,
Y is the yield (kg/ha)
W is the amount of water used by the crop (mm).

Yield may be dry matter or amount of carbon fixed etc. in plant level.WUE varies among species in the same environment among climates for the same crop among varieties of same crop. WUE of pineapple is about 20 g of dry matter perkilogram of water, 3 to 5 for C_4 plants and 2 to 3 C_3 plants.

Water Storage

- Rainfall can be stored directly in the soil for crop production using terraces, contour ridges, and other types of water retention methods.
- The experiment consisted of digging experimental trenches 80 cm deep, 5 m long and 1 m wide across the land slope between two row of olive trees, the trenches were filled up to the original soil level using local deposits of fractured rock and river sand with large infiltration rate.
- These filled trenches, called sand ditches, were expected to collect rainfall, intercept runoff, and store water in the surrounding soil at grater depths to be used by plants for longer periods of time.
- It can be a very efficient method since it increases water infiltration and prevents evaporation during the growing season.
- Sand ditches increased both the percentage of rainfall stored in soil matrix and the infiltration depth of water, the calculated ratio of depth of water stored in sand ditch area to rainfall was 73 per cent compared to only 45 per cent in the control area.