UNIT II

Tillage is as old as agriculture.

Jethro Tull – Father of tillage

After the harvest of crop the soil becomes hard and compact because of:

1. Beating action of rain drops.
2. Irrigation and subsequent drying
3. Movement of implements and labourers.

TILLAGE: It is the physical manipulation of soil with tools and implements to result in good tilth for better germination and subsequent growth of crops.

TILTH: It is the physical condition of soil resulting from tillage.

Objectives of Tillage

1. To produce a satisfactory seed bed for good germination and good crop growth.
2. To make the soil loose and porous.
3. To aerate the soil
4. To control weeds
5. To expose the soil inhabiting pathogens and insect pests to sun and kill them.
6. To break hard pans in the soil
7. For incorporating bulky organic manures
8. To warm up the soil
9. To increase infiltration rate.

Characteristics of a good seedbed

a) Uniformly firm soil to depth of 5 inches (12.7 centimeters)
b) Adequate soil moisture
c) Weed free.

Each of these characteristics help the seed to have the best chance to germinate and flourish.

- **Effects of Tillage on soil physical properties**

1. **Soil Structure:** Arrangements of soil particles with crumbly and granular nature is considered good. Best size of soil aggregate for good growth of crop is (1-5mm). Tillage improves soil structure when done at optimum soil moisture level.
2. **Soil texture:** Relative proportion of different soil particles namely sand, silt and clay.

   Coarse sand - 2.0 - 0.2mm.
   Fine sand - 0.2 - 0.02mm.
   Silt - 0.02 - 0.002mm.
   Clay - <0.002mm.

Tillage has no effect on soil texture.

3. **Pore space:** When a field is ploughed the soil particles are loosely arranged and pore space is increased. This facilitates free movement of air and moisture in soil.
4. **Bulk Density(B.D)**: When the soil is loosened, the soil volume increase without any affect on weight. BD of Clay soils is low (1.05 m^3 and that of sandy soils is high (1.25 – 1.30 m^3) and Bulk density of tilled soil is less than that of untilled soil. Particle density is always more than BD.
5. **Particle density:** Particle density is not altered by tillage.
6. **Soil Colour:** Organic matter is mainly responsible for the dark brown to dark grey colour of the soil. Tillage increases oxidation and decomposition of organic matter resulting in fading of colour.

Types of Tillage

Tillage operations are grouped into two types based on the time at which they are carried out.

1. Preparatory cultivation – which is carried out before sowing the crop
2. After cultivation – That is practiced after sowing the crop.

1. Preparatory tillage: This refers to tillage operations that are done to prepare the field for raising crops.

Types of preparatory tillage

a. Primary tillage

b. Secondary tillage

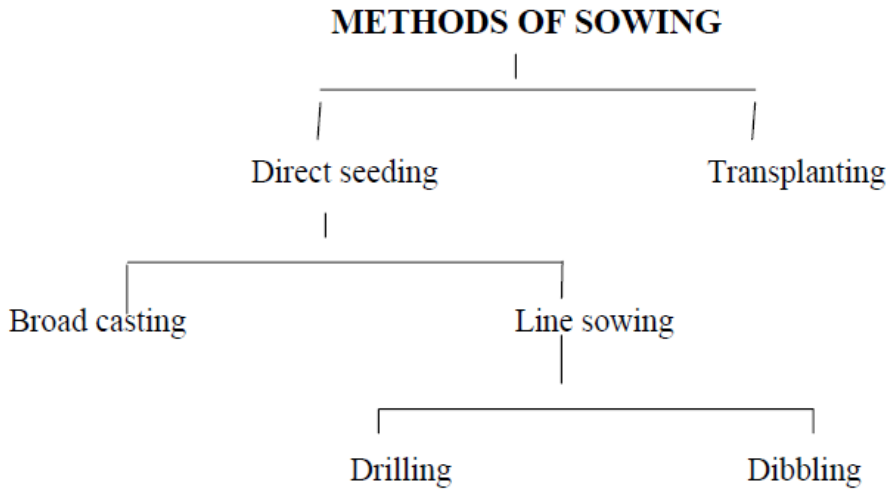
a. Primary tillage: The tillage operation that is done after the harvest of crop to bring the land under cultivation is known as primary tillage or ploughing. Ploughing is the opening of compact soil with the help of different ploughs. Examples: Country plough, mould board plough, tractor and power tiller drawn implements are used for primary tillage.

b. Secondary tillage: The tillage operations that are performed on the soil after primary tillage to bring a good soil tilth are known as secondary tillage. Secondary tillage consists of lighter or finer operation which is done to clean the soil, break the clods and incorporate the manure and fertilizers. Harrowing and planking is done to serve those purposes.

Planking is done to crush the hard clods, level the soil surface and to compact the soil lightly. Examples: Harrows, cultivators, Guntakas and spade are used for secondary tillage.

c. Layout of seed bed: This is also one of the components of preparatory tillage. Leveling board, buck scrapers etc. are used for leveling and markers are used for layout of seedbed. Country plough can be used.

2. After cultivation (Inter tillage): The tillage operations that are carried out in the standing crop after the sowing or planting and prior to the harvesting of the crop plants are called after tillage. This is also called as inter cultivation or post seeding/ planting cultivation. It includes harrowing, hoeing, weeding, earthing up, drilling or side dressing of fertilizers etc. Spade, hoe, weeders etc. are used for inter cultivation.



❖ Sowing

1.Broadcasting

Broadcasting is otherwise called as "random sowing". It means 'scattering the seeds'. Broadcasting is mostly followed for small sized to medium sized crops. It is the easiest and cheapest and requires minimum labors. If the seed is too small, it is mixed with sand to make a bulky one and for easy handling. Ex. Seasame seeds are mixed with sand at 1:15 or 1:10 ratio and sown.

2.Dibbling

This is actually line sowing. Inserting a seed through a hole at a desired depth and covering the hole. This is done for wider spaced crops and medium to large sized seeds.
Ex. Sorghum, maize, sunflower, cotton are dibbled on ridges and furrows.

3.Drill sowing (or) Drilling

Drilling is the practice of dropping seeds in a definite depth covered with soil and compacted. In this method, sowing implements are used for placing the seeds into the soil. Both animal drawn (Gorus) and power operated (seed drills) implements are available. In this method, fertilizer can also be applied simultaneously. It requires more time, energy and cost.

4.Transplanting

This method of planting has two components, a) nursery and b) transplanting. In nursery, young seedlings are protected more effectively in a short period and in a smaller area. Management is

easy and economical.

Time of sowing

1. Sowing very early in the season may not be advantageous.
   Eg: sowing rainfed ground nut early may result in failure of crop if there is prolonged dry spell from the 2nd week of june to 2nd week of july.
2. Delayed sowing invariably reduces yields
   Eg: rainfed sorghum yields are reduced due to delay in sowing beyond June season – sorghum sown late is subjected to severe at lack of shoot borer.
3. Advancing sowing of Rabi sorghum. From November-September to October. Increase the yields considerably as more moisture would be available for early sown crop.
4. Sowing the crop at optimum time.

Increases yields due to suitable environment at all the growth stages of the crop:

1. Optimum time of sowing for Kharif crop – June or July
2. Optimum time for Rabi crop - last week of October to first week of November
3. Summer crop - First fortnight of January.

Depth of Sowing

Uneven depth of sowing results in uneven crop stand.

1. The thumb rule is to sow seeds to a depth approximately 3-4 times their diameter.
2. The optimum depth of sowing for most of field crops ranges between 3-5 cm.
3. Shallow depth of sowing of 3-5 cm is enough for small seeds like sesame, finger millet and pearl millet.
4. Very small seeds like tobacco are placed at a depth of 1cm. Bold seeded crops like castor, groundnut, cotton and maize etc. 6-7 cm.

MANURES

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

a) Bulky organic manures - Farm Yard Manure (FYM), compost from organic waste, night soil, sludge, sewage, green manures.
b) Concentrated organic manures - oilcakes (edible, non-edible), blood meal, fishmeal and bone meal.

FERTILIZERS

Fertilizers are industrially manufactured chemical containing plant nutrients. Nutrient content is higher in fertilizers than organic manures and nutrients are released almost immediately. The fertilizers has three groups;

1. Straight fertilizers – supplies single nutrient Ex: Urea, Muriate of Potash
2. Complex fertilizers - supplies two or more nutrient Ex: 17:17:17 NPK complex
3. Mixed fertilizers- supplies two or more nutrient Ex: Groundnut mixture

❖ **Agronomic Interventions for Enhancing Field Use Efficiency (FUE)**

The following are the agronomic measures to improve the Fertilizer use efficiency (FUE).

1. Using best fertilizer source
2. Using adequate rate & diagnostic techniques
3. Usage of balanced fertilization
4. Integrated nutrient management
5. Utilization of residual nutrients

1. Using best fertilizer source

Identification of best source of fertilizer is pre-requirement for better crop production.

1. Nitrogen: Ammonical or Nitrate
2. Phosphorus: Water soluble or Citrate soluble
3. Potassium: Muriate of potash

2. Using adequate rate & diagnostic techniques

The fertilizer recommendation must be in adequate quantity so as to meet the demand of crop at any point of growth. The fertilizer supply is made by diagnosing its requirement by any of the following method.

a. Soil-test based fertilizer recommendations
b. Soil-test crop response based recommendation
c. Plant analysis for diagnosing nutrient deficiencies

3. Balanced fertilization

Balanced fertilization includes adequate supply of all essential nutrients, proper method of application, right time of application and nutrient interrelationships.

a. **Adequate supply of all essential nutrients:** Due to more concentration and application on primary nutrients (NPK), soils developed deficiency symptoms for secondary and micro-nutrients. Hence, ignored elements must be added to get higher yields in crops.
b. **Proper method**: Nitrogen and Potassium can be applied as broadcasting and band placement. Water soluble Phosphorous fertilizers are preferred to apply as band placement in neutral & alkaline soils. Micronutrients are applied in minor quantity as foliar sprays and water soluble fertilizers are applied in fertigation.

c. **Nutrient interrelationships:** Some of the fertilizer application in excess, cause loss of yield and quality of crops. Ex. Application of excessive 120 kg/hectare Phosphorous created an imbalance and reduced the seed and oil yields in soybean compared to 80 kg/hectare Phosphorous.

4. Integrated nutrient management

All the possible and available organic sources are to be utilized efficiently to reduce the usage of inorganic fertilizers.

Weed

Introduction

Father of weed science is **Jethro Tull**, he was 1st coin the term of weed

Definition of Weed: A weed is a plant growing where it is not desired (Jethro tull 1731 Great Britain farmer). Weed not only compete with crop plant but interfere agril operations, increasing labour cost.

Losses caused by weeds or harmful effect of weeds

1. Reduction in crop yield & production potentialities

Weeds compete with crops for water, nutrient & light. Weed account of 45% maximum yield loss in kharif than rabi season.

Wheat- 15-30%, Rice- 15-30%, Maize, sorghum, pulses, oilseeds- 15-25%.

2. Increase in cost of cultivation: Tillage operations are done to control weeds and it is generally estimated that on an average about 30 % of the total expenditure for crop production is on tillage operations.

3. The quality of livestock product is reduced

1) When some hungry animal feed on some weed crops their meat & milk are odd flavored.
2) Gokhru weed seeds get attached to body of sheep & damage the quality of wool.
3) Poisonous weed like Kala Dhotra cause death of cattle.

4. The quality of field produce is reduced: When the crop is harvested from a weedy field, the seeds of weeds get mixed with the main crop and consequently the quality of the produce is lowered.

5. Weed harbor insect pest & diseases: Weed either give shelter for various pest & disease or serve as alternate host. e.g. Physalis minima host of moisac disease.

6. Weed checks flow of water in irrigation channel: Weed blocks drainage & check flow of water & field channel increases the seepage losses as well as through over flowing.

7. Weed secretions are harmful: Weeds like lavala lower the germination & growth of many crop plants.

8. Weeds are harmful to human being: Carrot grass (*Parthenium hysterophorus*) & Poison Ivy (*Rhus spp*) are responsible for different kind of dermal allergies on human. Besides being injurious to the health of cattle, certain weeds cause irritation of skin, allergy and poisoning in human beings e.g. *Parthenium hysterophrous, Mimosa pudica*.

9. Weeds cause quicker wear & tear of farm: Implements: - Due to hardy and deep root system

10. Weeds reduce the value of land: Land which are heavily infested with perennial weeds like Kans always fetch les s price**.** e.g. *Sacharum spp, Pluchea spp*

11. Weeds contaminate water bodies: Aquatic weeds change the flavor, appearance, & taste of drinking water. Due to weeds reduce the production of edible fish.

12. Misutilization of weeds: Certain weeds have been used for adulteration from food in peace time & for toxicating mankind in war time. e.g. Rootstock of false hellebore (*veratrum spp*) were used to poison drinking water of enemy.

Principles of Weed Control

The principles of weed control are the basis for the development of the various methods of weed control and management. There are a number of ways to control weeds. They are based on these principles.

1. Prevention
2. Eradication
3. Control

Prevention of weed

The measures are adopted to deny or do not entry and establishment of new weeds in an cropped area called as weed prevention. The following different preventive measure are adopted for preventing further introduction & spread of weeds for minimizing weed population

1) Crop management practices

i) Growing crop varieties that grow fast as better competitors

ii) Proper placement of fertilizer, better irrigation practices.

2) Weed free crop seed

Separating crop seeds from mixture of crop & weed seed during physical separation.

a) Farm implements should be cleaned before using them in other fields.

3) Seed certification

Seed certification helps in supplying genetically pure seeds & propagating materials of crops to farmers. In India NSC (National Seed Corporation) take the responsibility of certifying crop seeds.

4) Weed laws

Weed laws are important in reducing the spread of weed species. There is no weed laws in India except Karnataka which declare parthenium hysterophorus as a noxious weed.

Weed eradication

Eradication means complete removal or elimination of both living weed seeds and seed present in soil from an area called weed eradication. The soil sterilants may be used for complete eradication of weeds in non- cropped & bare lands.

Control of weed

Weed control is the process to limit the growth of unwanted plants from cultivated fields.

Methods or Practices of Weed Control

Weed management method is broadly grouped into preventive & curative and further broadly categorized into mechanical, cultural (Agronomical), biological & chemical methods.

i) Preventive measures: Two dimension

Time:- prevent infestation prior to weed germination

Space:-Prevent introduction or spread to new areas.

ii) Curative Methods

1. **Mechanical method of weed control**

a) Hand pulling or hand weeding: Pulling the weed by hand or weeding with the help of weeding hook or locally called khurpi.

b) Tillage

1. Deep ploughing: Weeds are buried deep in the soil & exposed to heat of sun by deep ploughing.

2. Disc harrow : Disc harrow are helpful for cutting & burring of weed into soil. weeds in between crop rows.

3. Mowing and sickling: The implement mower is used for cutting weeds. Cutting above ground parts of weed with sickle is called sickliing.

c) Burning/fire

It is adopted to destroy weeds in non-cropped areas like waste land, road sides, railway lines & bund. Burning is the cheapest method of elimination mature unwanted plant.

d) Mulching: The principle aim of this method to cut off light & avoid all top growth of weeds.

2. **Cropping and cultural method**

   a) Crop rotation: The proper crop rotations or inclusion of pulse crops in rotation is helpful for control of crop associated weeds.

   b) Use of fertilizer: Some fertilizer like calcium cynamide & ammonium sulphate direct destroy the delicate weeds.

   c) Summer tillage: Deep ploughing after harvest of the rabi crop and exposing underground part of weeds to strong sunlight during summer months is helpful for destroying many annual and perennial weeds.

3. **Biological weed control:** Biological control of weeds involves the use of living organisms against them. These living organisms called bioagents could be insects, disease organisms, herbivorous fish, snails etc.

4. **Chemical methods**

Fluchloralin (Basalin) @ 0.5 to 1 kg / ha or pendimethalin @ 1.2 to 1.5 kg /ha. as pre-plant incorporation (PPI) also found effective as compared to pre-emergence treatment.

Dryland farming: is cultivation of crops in regions with annual rainfall less than 750 mm. In spite of prolonged dry spells crop failure is relatively less frequent. Moisture conservation practices are necessary for crop production.

Problems or constraints for crop production in dry farming regions

The low productivity of agriculture in dry farming regions is due to the combined effect of many constraints for crop production. The constraints can be broadly grouped in to

1. Climatic constraints,
2. Soil related constraints,
3. Traditional cultivation practices
4. Heavy weed problem
5. Lack of suitable varieties and
6. Socio economic constraints.

1. Climatic constraints

A) Rainfall characteristics: Among the different climatic parameters rainfall is an important factor influencing the crop production in dry regions

(i) Variable rainfall: Rainfall varies both in time and space dimension. Annual rainfall varies greatly from year to year and naturally its coefficient of variation is very high. More than one third of total geographical area in India receive rainfall less than 750 mm (Table.3.1)

Table 3.1 Classification of India into different zones based on rainfall

Zone	Average annual rainfall (mm)	Per cent of geographical area
Zone I (very low rainfall area)	< 350	13
Zone II (low rainfall area)	350 to 750	22
Zone III (Medium rainfall area)	750 to 1125	36
Zone IV (High rainfall area)	> 1125	29

(ii) Intensity and distribution: In general, more than 50 per cent of total rainfall is usually received in 3 to 5 rainy days Distribution of rainfall during the crop growing season is more important than total rainfall in dryland agriculture.

iii) Aberrations or variations in monsoon behaviour

(a) Late onset of monsoon: If the onset of monsoon is delayed, crops/varieties recommended to the region cannot be sown in time. Delayed sowing lead to uneconomical crop yields.

(b)Early withdrawal of monsoon: This situation is equally or more dangerous than late onset of monsoon. Post-rainy season crops fail due to inadequate available soil moisture, especially during reproductive and maturity phases.

(c) Prolonged dry spells: Breaks of monsoon for 7-10 days may not be a serious concern. Breaks of more than 15 days duration especially at critical stages for soil moisture stress leads to reduction in yield.

2. Soil Constraints

The different soil groups encountered in dryland areas are black soils, red soils and alluvial soils. The constraints for crop production are different in different soil groups. The different soil constraints for crop production are

a) Inadequate soil moisture availability: The moisture holding capacity of soils in dry regions is low due to shallow depth especially in alfisols (red soils), low rainfall and low organic matter content.

b) Poor organic matter content: The organic matter content in most of the soils under dryland conditions is very low (< 1 %) due to high temperature and low addition of organic manures.

c) Poor soil fertility: Most of the dry land soils are deficient in nitrogen and zinc.

d) Soil deterioration due to erosion (wind, water): The erosion causes loss of top fertile soil leaving poor sub soil for crop cultivation.

e) Soil crust problem: In case of red soils, the formation of hard surface soil layers hinders the emergence of seedlings which ultimately affect the plant population.

f) Presence of hard layers and deep cracks: Presence of hard layers (pans) in soil and deep cracks affect the crop production especially in case of black soils.

3. Traditonal Cultivation practices

The existing management practices adopted by the farmers are evolved based on long term experience by the farmers. The traditional management practices are

a) Ploughing along the slope
b) Broadcasting seeds
c) Application FYM in limited quantity
d) Hand weeding
e) Use of conventional system of harvesting

4. Heavy weed infestation: This is the most serious problem in dryland areas. Unfortunately the environment favorable for crop growth is also favorable for weed growth.

5. Lack of suitable varieties: There are no any special varieties exclusively meant for dryland areas. Hence still more efforts are required to develop varieties in different crops exclusively meant for dryland agriculture.

6. Socio-economic constraints: The economic condition of the dryland farmers is very poor because

a) Less access to inputs

b) Non availability of credit in time

c) The risk bearing capacity of dryland farmer is very low

Hence the dryland farmers resort to low input agriculture which results in poor yields.

Evapotranspiration and measures to reduce evapotranspiration

Definition

Under dry land conditions soil moisture is the most limiting factor for crop production. It is lost as evaporation from soil surface and as transpiration from the plant surfaces. The combined loss of moisture through these two processes is known as evapotranspiration.

Methods to reduce evaporation

There are three principles of evaporation control under field conditions.

1. Decreasing the turbulent transfer of water vapour to the atmosphere by growing plants, raising wind breaks, straw mulches etc.,
2. Decreasing capillary conductivity by rapid drying of the surface soil layers.
3. Decreasing the capillary flow and moisture holding capacity of the surface soil layers.

For evaporation control, mostly mulches are used.

Mulches

Mulch is any covering material applied on the soil surface to reduce evaporation losses. This material may be grown and maintained in place, or any material grown and modified before placement or any material processed or manufactured and transported before placement.

Types of mulches

a. Soil mulch or dust mulch
b. Straw and stubble mulch
c. Plastic mulches
d. Chemical mulches
e. Vertical mulching
f. Live mulching, Eg. Sorghum + forage cowpea, sorghum + sword bean
g. Pebble mulch

Reducing losses due to transpiration

Nearly 99% of water absorbed by the plant is lost in transpiration. Hence transpiration reduction is needed for maintaining favorable water balance in the plants. Transpiration has become unavoidable evil as the stomata, which allow CO_2 exchange also allows water vapour transfer into the atmosphere.

There are four principles of transpiration control

1. By increasing leaf resistance to water vapour transfer by application of materials, which tend to close or cover stomata (ex: both stomatal closing and film forming type of antitranspirants).
2. By reducing amount of energy absorbed by leaf surface (Eg: leaf reflectants)
3. By reducing top growth of plants (Eg: Growth retardants)
4. By increasing air resistance to water vapour transfer by shelter belts/ wind breaks

Organic farming: Organic farming is a production system where all kinds of agricultural products are produced organically, including grains, meat, dairy, eggs, fibers such as cotton, flowers and processed food products.

Organic farming avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators and livestock feed additives.

Advantages of organic farming

1. Nutrition - Improved soil health makes food dramatically superior in mineral content
2. Poison-free - Free of contamination with health harming chemicals like pesticides, fungicides and herbicides.
3. Food tastes better
4. Food keeps longer - can be stored longer
5. Disease and pest resistance - because of healthy plants
6. Lower input costs - No costly chemicals used, nutrients are created in-situ (in the farm)
7. More profitable - Due to greater food value of organic produce consumers are willing to pay premium prices

Disadvantages of organic farming

1. Productivity - Low productivity is often reported as the quantum nutrient used comparatively lower
2. Labour intensive - Cultivation requires more labour especially for weed control

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."

Sustainable agriculture is a type of agriculture that focuses on producing long-term crops and livestock while having minimal effects on the environment. This type of agriculture tries to find a good balance between the need for food production and the preservation of the ecological system within the environment. In addition to producing food, there are several overall goals associated with sustainable agriculture, including conserving water, reducing the use of fertilizers and pesticides, and promoting biodiversity in crops grown and the ecosystem.

Advantages

1. Production cost is low
2. Overall risk of the farmer is reduced

3. Pollution of water is avoided
4. Very little or no pesticide residue is ensured
5. Ensures both short and long term profitability

Disadvantages

- Since sustainable agriculture uses least quantum of inputs, naturally the output (yield) may also be less.

❖ **Critical growth stages and water requirements of important crops**

Crop	Critical growth stages	Average crop duration (days)	Water requirement (mm)
Rice	Tiller initiation, flowering and milky stage	90-130	900-2500
Wheat	Crown root initiation, flowering, joining, milky and tillering	135	400-450
Pulses	Flower initiation and pod filling	90-120	250-300
Groundnut	Pegging and pod formation	105	450-600
Sugarcane	Emergence, tiller formation and elongation	330	1400-3000
Banana	Early vegetative phase, bunch initiation and flowering	300	3000
Maize	Silking and cob development	100	400-600
Sorghum	Knee-height stage, flowering and grain filling	100-120	250-300
Cotton	Commencement of sympodial branching, flowering, boil formation and boil bursting	165	600-700

Crop Seasons

Crops are grouped under the seasons in which their major field duration falls.

a) Kharif crops: Crops grown during June-July to September–October which require a warm wet weather during their major period of growth and shorter day length for flowering.

b) Rabi crops: Crops grown during October–November to January-February, which require cold dry weather for their major growth period and longer day length for flowering.

c) Summer crops: Crops grown during February–March to May–June which require warm dry weather for growth and longer day length for flowering.