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12. Modern Concepts of Tillage

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Abstract:

The term "tillage" embraces a range of operations applied prior to sowing, to prepare the soil for crop growth. These operations are using various types of implements and machinery to loosen, invert, and mix the soil, modify the surface configuration, change aggregate size, incorporate materials (fertilisers, manure, crop residues, etc.), eradicate weeds, and form openings for seed placement. The need for and aims of tillage are various and may include: the production of favourable conditions for seed germination, seedling emergence, rainwater infiltration, soil moisture retention, root development and growth of tubers; the modification of soil aeration and soil temperature; the management of weeds, crop residues, pests and diseases; the elimination of pastures in crop-pasture rotations; the incorporation of fertilisers, green manure and soil amendments.

However, in many situations these objectives can be better achieved through zero tillage or other forms of conservation tillage than through conventional tillage, and usually with the added benefits of savings in cost and labour, together with improvements in soil health over the medium to long term.

It is therefore crucial in ISNM courses that attention focuses on whether conventional tillage, or tillage of any kind, is really necessary for the local soils, climate, cropping and farming systems, and farmers socio-economic conditions. Often zero or other forms of conservation tillage will be more beneficial than conventional tillage, but experiments will often be necessary to find the optimum tillage system. A description of a tillage system will include details of the types of machinery and tillage implements used for each crop in the rotation, the specifications, settings, working velocity, depth of operation, number of passes, timing and sequence of the different tillage operations, together with details of the seeding and stubble management machinery employed.

Keywords:

Tillage, primary tillage, secondary tillage, crop residues, mulches and manures.

12.1 Introduction:

A. Classification:

A very large number of different tillage systems and implements powered by tractors, animals and by hand, are in use in different parts of the world. To facilitate the discussion of tillage systems, they have been classified into three categories (see below for details): "conventional tillage" signifying a high degree of soil disturbance, "reduced tillage" in which one or more of the conventional tillage operations are eliminated, and "conservation tillage" in which there is minimal soil disturbance and crop residues are, if at all possible, left on the surface to protect and benefit the soil.

The term "minimum tillage" is not used to avoid confusion which arises from the many different meanings of this term as used in different parts of the world. In particular, conservation tillage normally refers to tillage systems that do not invert the soil, which retain crop residues on the surface, and which optimize soil and water conservation. It has been defined as "any tillage or planting system in which at least 30 % of the soil surface is covered by plant residue after planting to reduce erosion by water; or where soil erosion by wind is the primary concern, with at least 1 t/ha of flat small grain residue on the surface during the critical wind erosion period" (CTIC, 1993). Conservation tillage is thus a broad term which includes zero tillage, strip tillage, tine tillage and ridge tillage.

B. Advantages of Tillage:

- Improved soil conditions due to decomposition of plant residues in *situ.*
- Higher infiltration caused by the vegetation present on the soil and channels formed by the decomposition of dead roots.
- Less resistance to root growth due to improved structure.
- Less soil compaction by the reduced movement of heavy tillage vehicles and less soil erosion compared to conventional tillage.

Note: These advantages are evident on course and medium textured soils and appear after two to three years of practicing minimum tillage.

C. Disadvantages of Minimum Tillage:

- Seed germination is lower with minimum tillage.
- In minimum tillage, more nitrogen has to be added as rate of decomposition of organic matter is slow.
- Nodulation is affected in some leguminous crops like peas and broad beans.

- Sowing operations are difficult with ordinary equipment.
- Continuous use of herbicides causes pollution problems and dominance of perennial problematic weeds.

D. Different methods of minimum tillage practiced:

a. Row Zone Tillage: After primary tillage with mould board plough, secondary tillage operations like disking and harrowing are reduced. The secondary tillage is done in the row zone only.

b. Plough-plant Tillage: After the soil is ploughed, a special planter is used and in one run over the field, the row zone is' pulverised and seeds are sown.

c. Wheel Track Planting: Ploughing is done as usual. Tractor is used for sowing and the wheels of the tractor pulverise the row zone.

d. Zero Tillage: Zero tillage is also called as no till. Zero tillage is an extreme form of minimum tillage. Primary tillage is completely avoided, and secondary tillage is restricted to seedbed preparation in the row zone only. Till planting is one method of practicing zero tillage. The machinery accomplishes four tasks in one operation: clean a narrow strip over the crop row, open the soil for seed insertion, place the seed and cover the seed properly.

A wide sweep and trash bars clear a strip over the previous crop row and planter-shoe opens a narrow strip into which seeds are planted and covered. In zero tillage, herbicide functions are extended. Before sowing, the vegetation present has to be destroyed for which broad spectrum, non-selective herbicides with relatively short residual effect (Paraquat, Glyphosate etc.,) are used.

12.2 Till Planting:

A. Stubble mulch Tillage:

Conventional method of tillage results in soil erosion. Stubble mulch tillage or stubble mulch farming a new approach was developed for keeping soil protected at all times whether by growing a crop or by crop residues left on the surface during fallow periods.

It is a year-round system of managing plant residue with implements that undercut residue, loosen the soil and kill weeds. Sweeps or blades are generally used to cut the soil up to 12 to 15cm depth in the first operation after harvest and the depth of cut reduced during subsequent operations.

When unusually large number of residues are present, a disc type implement is used for the first operation to incorporate some of the residues into the soil. This hastens decomposition, but still keeps enough residues on the soil.

B. Two methods are adopted for sowing crops in stubble mulch farming:

a. Similar to zero tillage, a wide sweep and trash-bars are used to clear a strip and a narrow planter-shoe opens a narrow furrow into which seeds are placed.
b. A narrow chisel of 5 to 10 cm width is worked through the soil at a depth of 15 to 30 cm leaving all plant residues on the surface.

The chisel shatters tillage pans and surface crusts. Planting is done through residues with special planters.

- Tillage is as old as agriculture. Primitive man used to disturb the soil for placing seeds. Jethro Tull who is consider as father of tillage, proposed a theory that plant absorb minute particle of soils. Therefore, he suggested that thorough ploughing and other operations were necessary so as to make soil into fine particles. Though his theory is not correct, tillage operation is carried out to prepare a fine seed bed for sowing crops.
- After harvest of the crop, soil becomes hard and compact. Beating action of rain drops, irrigation and subsequent drying, movement of inter cultivation implements and labour cause soil compaction, Field contains weeds and stubbles after the harvest of crops, Seeds need loose, friable soil with sufficient air and water for good germination. The field should be free from weeds to avoid competition with the crop that follows. It should also be free from stubbles to facilitate easy and smooth movement of sowing implements.
- Tillage is the physical manipulation of soil with tools and implements to result in good tilth for better germination and subsequent growth of crops. Tilth is a physical condition of the soil resulting from tillage.

12.2.1 Purpose of Tillage:

The purpose of tillage is to prepare a seedbed, break weed, insect and disease cycles, burry plant residues, incorporate fertilizers and amendments, break surface crust and fracture plough pans or hard subsoil horizons.

12.2.2 Objectives of Tillage:

There are several objectives of tillage of which the most important are suitable seedbed preparation, weed control and soil and water conservation. The other objectives are:

- Adequate seed-soil contact to permit water flow to seed and seedling roots. Intimate contact between the soil particles is necessary to facilitate movement of water for quick germination.
- Tillage improves soil aeration, which helps in multiplication of microorganism. Organic manures decomposition is enhanced resulting in higher nutrient availability. Increased aeration also helps in degradation of herbicides and pesticides residues and harmful allopathic chemicals exuded by roots of previous crop or weeds.
- Weed control is an important object of tillage. Two or three deep ploughing in during summer controls problematic weeds like *nutsedge orchido* (*Cyperus rotundus.* L.)

- Proper tillage results in soil and moisture conservation through higher infiltration, reduced runoff and increase depth of soil for moisture storage. When compact soil is plough, it becomes fluffy (soft or loose or friable) and can hold more amount of water. Removal of hardpans increases the soil depth for water absorption, surface roughness and furrow dikes slowdown the velocity of runoff and provide more time for infiltration of water.
- Break the compacted layers to increases soil permeability and helps to increase of root penetration due to breaking hard pans and compacted layers.
- Tillage helps to incorporate weeds, crop residues, green manures and other organic manures and fertilizers, soil amendment anti other agro chemicals applied for the control of weeds, insect and pest etc. to reduce volatilization losses.
- Tillage exposes the lower soil to weather and replaces the surface soil under earth. Many of the insects remain dormant as pupae in the top layer of the soil. As a result of tillage insect-pest come out and destroy by beat and birds and predatory animals.
- Tillage helps to check loss of water through percolation in low land paddy fields by making an impervious soil low layer (hard pan) and also makes the soil level and flat those are suitable for uniform movement of irrigation water.
- The tillage prepares good seed bed which is necessary for early seed germination and initial good stand of the crop and improves the soil structures.
- The stubbles of previous crop, which harbors insect pests, arc removed following tillage resulting in reduced pest attack on the succeeding crop.
- The improve soil structure can be produced by tilling the soil at proper time when the soil moisture is optimum. Tillage operation carried out at improper soil moisture damage soil structure and leads to develop hard pans.
- Control of soil erosion on sloppy land, tillage across the slope of field will create furrow dikes, which slow do the velocity of runoff rain or irrigation water and consequently reduced soil erosion. Before rainy season the fields are left cloddy, to prevent erosion and increase the water storage in the soil. This is the good practice under dry farming situation,

12.3 Tillage Influence on Physical Properties of Soil:

Tillage has considerable influence on soil physical properties like pore space, structure, bulk density, water content and color. These effects of tillage lost for about a month. Tillage practices have therefore, greatest effect on seed germination, seedling emergence and stand establishment.

A. Pore Space:

Soils are made up of particles of different sizes. Air filled spaces between these particles constitute pore space.

When a field is ploughed, the soil particles are loosely stacked in a random manner and pore space is increased, When the soil is in good tilth, the, capillary and non-capillary pores would be roughly equal. This facilitates free movement of air and moisture in the soil and increases infiltration.

B. Soil Structure:

Soil with crumbly and granular clods is considered as soils with good structure. When the soil is subjected to tillage at optimum moisture, crumb structure is developed so that loss of soil by erosion is greatly reduced. Rain Water is held in the large pores, between the aggregates and also in the Microspore pores of the aggregates. It is considered that soil aggregates of 1 to 5 mm in size are favourable for growth of plants. Smaller aggregates may clog the soil pores and larger ones may have large pore space between them and affect the development of rootlets of the young seedlings. Soil structure is destroyed when tillage is carried out at inappropriate soil moisture.

C. Bulk Density:

When the soil is loosened, the soil volume increases without any effect on weight. Therefore, bulk density of tilled soil is less than the untilled soil.

D. Soil Colour:

Organic matter is mainly responsible for the dark brown to dark grey colour of the soil. Tillage increases oxidation and decomposition resulting in fading of colour.

E. Soil Water:

Tillage improves soil water in different ways. The amount of available water depends on soil porosity, soil depth and random roughness. All these characters are increased by tillage. Roughness is a measure of micro elevations and depression caused by furrows and ridges, clods and depression. Random roughness indicates elevation and depressions of the field without a pattern as it happens after ploughing. It influences the volume of surface-depression storage or temporary storage of rainfall. Tillage also increases rate of infiltration, water holding capacity and hydraulic conductivity.

F. Soil Temperature:

Tillage creates soil temperature optimum for seed germination and seedling establishment. Tillage loosens the soil surface resulting in decrease of thermal conductivity and heat capacity.

12.4 Types of Tillage:

Tillage operations are grouped into two types based on the time (with reference to crop) at which they are carried out. They are:

A. Preparatory cultivation: Tillage operations that are carried out to prepare seedbed before sowing of crop from the time of harvest of a crop to the sowing of the next crop are known as preparatory cultivation. Preparatory cultivation consists of three distinct operations viz. primary tillage, secondary tillage and layout of seedbed.

B. Primary Tillage or Ploughing:

Ploughing is opening of the compacted soil with the help of different ploughs. Ploughing is done mainly to open the hard soil. In addition, ploughing should ensure inversion (whenever necessary) of soil, uprooting of weeds and stubbles and less cloddy soil surface.

Optimum time of ploughing: The correct time for ploughing depends on soil moisture. When the soil is dry it is difficult to open the soil, more energy is used and large sized clods result. When the soil is ploughed under wet conditions, the soil sticks to plough, the soil below the plough sole becomes compacted and on drying becomes a hard pan, soil structure is destroyed and the clods on drying become very hard. The optimum range of soil moisture for effective ploughing is 25 to 50 per cent depletion of available moisture. Light soils can be ploughed in a wide range of soil moisture conditions while the range is narrow for heavy soils.

Depth of ploughing: Depth of ploughing mainly depends on the effective root zone depth of the crops. Generally, crops with tap root system require greater depth of ploughing, while fibrous, shallow rooted crop require shallow ploughing.

C. Number of Ploughings:

The number of ploughings necessary to obtain a good tilth depends on soil type, weed problem and crop residues on the soil surface. In heavy soils, a greater number of ploughings are necessary, the range being 3 to 5 ploughings, Light soil requires 1 to 3 ploughings to obtain proper tilth or the soil. When weed growth and plant residues are higher, a greater number of' ploughings are necessary.

D. Selection of Ploughs: Depending on the purpose, soil condition and nature of weed problem, different ploughs are used.

Table 12.1: Suitable Ploughs for Different Situations

Plough	Situation or purpose
Mouldboard plough (M. B. Plough) (Tractor drawn)	Deep ploughing and inversion
Mouldboard plough (Animal drawn)	Incorporation of manures, fertilizer and plant residue
Disc plough	Cutting of creeping or spreading grass and inversion
Country plough	Multipurpose

Types of primary tillage: Depending on the purpose or necessity, different types of tillage are carried out. They are deep ploughing, subsoiling and year-round tillage. Deep tillage or deep ploughing: In western countries, deep ploughing is 50 cm depth for rainfed conditions and 70 cm depth for irrigated conditions. Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad classified ploughing according to depth as under:

Table 12.2: Different Types of Ploughing Categories

Depth	Categories
5-6 cm	Shallow ploughing
15-20 cm	Medium deep ploughing
25-30 cm	Deep ploughing

Deep ploughing turns out large sized clods that are baked by the hot sun when it is done in summer. These clods crumble due to alternate heating and cooling and due to occasional summer showers. This process of gradual disintegration of clods improves soil structure. The rhizomes and tubers of perennial weeds (World's problematic weeds viz, *Cynondon dactylon* and *Cyperus rotundus*) die due to exposure to hot sun. Summer deep ploughing kills pests due to exposure of pupae to hot sun and attack of birds and predators.

Deep tillage also improves soil moisture content; however, the advantage of deep tillage in dry farming condition depends on rainfall pattern and crop. There is no yield advantage if rainfall below normal. The residual effect of deep tillage is marginal. Therefore, it is advisable to go for deep tillage ploughing only for long duration, deep rooted crops.

Sub soiling: Hard pans may be present in the soil, which restrict root growth of crops. These may be slit pans, iron or aluminum pans, clay pans or manmade pans are tillage pans induced by repeated tillage at the same depths. These are present in most of the Indian soils.

Root growth of crops is confined to top few cm of soil where deep penetration of roots is inhibited by hard pans. For example, cotton roots grow to a depth of 2 m in deep alluvial soil without any pans when hard pans. They grow only up to hard pan, say 15-20 cm. Similarly vertical root growth of sugarcane is restricted due to hard pans, and it is not compensated by horizontal spread. Sub soiling is breaking the hard pan without inversion and with less disturbance of topsoil.

Year-round tillage: Tillage operations carried out throughout the year are known as year-round tillage. In dry farming regions, field preparation is initiated with the help of summer showers. Repeated tillage operations are carried out until sowing of the crop. Even after harvest of the crop, the field is repeatedly or harrowed to avoid weed growth in the off-season.

E. Secondary Tillage:

Lighter or finer operations performed on the soil after primary tillage is known as secondary tillage. After ploughing, the field is left with large clods with some weeds and stubbles partially uprooted. Harrowing is done to a shallow depth to crush the clods and to uproot remaining weeds and stubbles. Disc harrows, cultivators, blade harrow etc., are used for this purpose. Planking is done to crush the hard clods to smooth the soil surface and to compact the soil lightly. Thus, the field is made ready for sowing after ploughing by harrowing and planking. Generally sowing operations are also included in secondary tillage.

Layout of seedbed and sowing: After the seedbed preparation, the field is laid out properly for irrigation and sowing or planting seeding. These operations are crop specific. For most of the crops like wheat, soybean, pear millet, groundnut, castor etc., flat leveled seedbed is prepared.

For some crops like maize, vegetables etc., the field has to be laid out into ridges and furrows. Sugarcane is planted in the furrows or trenches. Crops like tobacco, tomato, chilly are planted equal inter and intera-row spacing so as to facilitate two-way inter-cultivation. Setline planting is adopted in Gujarat for sowing cotton and groundnut. Every year, seed rows are in the same place, since the seed lines are set permanently at wider spacing. The inter-row space is not cultivated.

After field preparation, sowing is done with seed drills. These seeds are covered by running blade harrow to a shallow depth followed by planking so as to level and impart necessary compaction. Sowing is also done by dropping seeds behind the country plough.

F. After Tillage or After Cultivation:

The tillage operations that are carried out in the standing crop are called after tillage. It includes drilling or side dressing of fertilizers, earthing up inter-cultivation. Earthing up is an operation carried out with country plough or ridge plough so as to form ridge at the base of the crop.

It is done either to provide extra support against lodging as in sugarcane or to provide more soil volume for better growth of tubers as in potato or to facilitate irrigation as in the vegetables. Inter-cultivation is working blade harrows, rotary hoes etc., in between the crop measure by closing deep cracks in black soils.

12.5 Modern Concept of Tillage:

In conventional tillage, the soil is opened with mouldboard plough for primary tillage. Subsequently, a fine seedbed is prepared by secondary tillage. In this process, energy is often wasted and sometimes, soil structure is destroyed. Recently, considerable change has taken place in tillage practices and several new concepts have been introduced, namely, minimum tillage, zero tillage, stubble mulch farming etc.

A. Minimum Tillage:

The concept of minimum tillage is started in USA. Minimum tillage is aimed at reducing tillage to the minimum necessary for ensuring good seedbed, rapid germination, a satisfactory stand and favourable growing conditions.

Minimum tillage has certain advantages: Improved soil condition due to decomposition of plant residues in *situ;* higher infiltration caused by the vegetation present in the soil and channels formed by the decomposition of dead roots; less resistance to root growth sue to improved structure; less soil compaction by the reduced movement of heavy tillage vehicles and less soil erosion compared to conventional tillage. However, these advantages are evident on course and medium textured soils and appear after two to three years of practicing minimum tillage.

There are certain disadvantages of minimum tillage. Seed germination is lower minimum tillage. In minimum tillage, more nitrogen has to be added as rate of decomposition of organic matter is slow. Nodulation is affected in some leguminous crops like peas. Sowing operations are difficult with ordinary equipment. Further, continuous use of herbicides causes pollution problems and dominance of perennial problematic weeds.

Minimum tillage can be practiced by different methods as given below:

Row zone tillage: After primary tillage with mouldboard plough, secondary tillage operations like discing and harrowing are reduced. The secondary tillage is done in the row zone only.

Plough-plant tillage: After the soil is ploughed, a special planter is used and in one run over the field, the row zone is pulverized, and seeds are sown.

Wheel track planting: Ploughing is done as usual. Tractor is used for sowing and the wheels of the tractor pulverize the row zone.

B. Zero Tillage:

Zero tillage is an extreme form of minimum tillage. Primary tillage is completely avoided and secondary tillage is restricted to seedbed preparation on the row zone only. It is also known as no-till and is resorted to where soils are subjected to wind and water erosion, timing of tillage operation is too difficult and requirements of energy and labour for tillage is too high. Zero tilled soils are homogenous in structure with a greater number of earthworms. The organic matter content increases due to less mineralization. Surface runoff is reduced due to the presence of mulch. The favourable effects of zero tillage on soil physical properties are apparent after two years of its practice.

Till planting is one method of practicing zero tillage. The machinery accomplishes four tasks in one operation: clean a narrow strip over the crop row, open the soil for seed insertion, place the seed and cover the seed properly. A wide sweep and trash bars clear a strip over the previous crop row and planter-shoe open a narrow strip into which seeds are

planted and covered. In zero tillage, herbicide functions are extended. Before sowing, the vegetation present has to be destroyed for which broad spectrum, nonselective herbicides with relatively short residual effect (paraquat, glyphosate etc.,) are used. During subsequent stages, selective and persistent herbicides are needed. The herbicides applied should not cause injury to the succeeding crop.

The seedling establishment in zero tillage is 20 per cent less than in conventional methods. High dose of nitrogen has to be applied as mineralization of organic matter is slow in zero tillage. Large populations of perennial weeds appear in zero tilled plots. Higher number of volunteer plants and buildup of pests are the other problems.

C. Stubble Mulch Tillage:

The traditional methods of tillage developed in temperate moist climates based on mouldboard plough, often increase soil erosion when adopted indiscriminately in arid land cultivation. A new approach was developed for keeping soil protected at all times whether by growing a crop or by crop residues left on the surface during fallow periods. It is known as stubble mulch tillage or stubble mulch farming. It is a year-round system of managing plant residue with implements that undercut residue, loosen the soil and kill weeds. Soil is tilled as often as necessary to control weeds during the interval between two crops. Good management of stubble mulch farming system begins with harvest of the crop. Sweeps or blades are generally used to cut the soil up to 12 to 15 cm depth in the first operation after harvest and the depth of cut reduced during subsequent operations. When unusually large amount of large number of residues are present, a disc type implement is used for the first operation to incorporate some of the residues into the soil. This hastens decomposition, but still enough residues on the soil.

Stubble mulch tillage, however, presents practical problems. The residues left on the surface interfere with seedbed preparation and sowing operations. The traditional tillage and sowing equipment is not suitable under these conditions. Two methods are adopted for sowing crops in stubble mulch farming.

Similar to zero tillage, a wide sweep and trash-bars are used to clear a strip and a narrow planter-shoe opens a narrow furrow into which seeds are placed.

A narrow chisel of 5 to 10 cm width is worked through the soil at a depth of 15 to 30 cm leaving all plant residues on the surface. The chisel shatters tillage pans and surface crusts. Planting is done through residues with special planters.

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D. Tillage:

Tillage operations in various forms have been practiced from the very inception of growing plants. Primitive man used tools to disturb the soils for placing the seeds. The word tillage is derived from ‘Anglo-Saxon’ words *Tilian*and *Teolian,* meaning to plough

and prepares oil for seed to sow, to cultivate and to raise crops. **Jethrotull,** who is considered as father of tillage suggested that thorough ploughing is necessary so as to make the soil into fine particles.

a. Tillage is the mechanical manipulation of soil with tools and implements for obtaining conditions ideal for seed germination, seedling establishment and growth of crops.
b. Tilth is the physical condition of soil obtained out of tillage (or) it is the result of tillage. The tilthmay be a coarse tilth, fine tilth or moderate tilth.

E. Objectives of tillage:

The main objectives of tillage are,

- To prepare a good seed bed which helps the germination of seeds.
- To create conditions in the soil suited for better growth of crops.
- To control the weeds effectively.
- To make the soil capable for absorbing more rainwater.
- To mix up the manure and fertilizers uniformly in the soil.
- To aerate the soil.
- To provide adequate seed- soil contact to permit water flow to seed and seedling roots.
- To remove the hard pan and to increase the soil depth.
- To achieve these objectives, the soil is disturbed/ opened up and turned over.

F. Types of tillage:

Tillage operations may be grouped into

a. On season tillage b. Off-season tillage

On-season tillage:

Tillage operations that are done for raising crops in the same season or at the onset of the crop season are known as on-season tillage. They may be preparatory cultivation and after cultivation.

Preparatory tillage: This refers to tillage operations that are done to prepare the field for raising crops. It consists of deep opening and loosening of the soil to bring about a desirable tilth as well as to incorporate or uproot weeds and crop stubble when the soil is in a workable condition.

12.6 Types of Preparatory Tillage:

- **Primary tillage**
- **Secondary tillage**

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. Country plough, mould board plough, bose plough, tractor and power tiller drawn implements are used for primary tillage.

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. Harrows, cultivators, Guntakas and spade are used for secondary tillage.

Layout of seedbed*:* 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.

A. 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.

B. Off-Season Tillage:

Tillage operations done for conditioning the soil suitably for the forthcoming main season crop are called off-season tillage. Off season tillage may be, post-harvest tillage, summer tillage, winter tillage and fallow tillage.

a. **Special purpose tillage:** Tillage operations intended to serve special purposes are said to be special purpose tillage. They are,
b. **Sub-soiling:** To break the hard pan beneath the plough layer, special tillage operation (chiseling) is performed to reduce compaction. Sub-soiling is essential and once in four to five years where heavy machineries are used for field operations, seeding, harvesting and transporting. Advantages of sub-soiling are, greater volume of soil may be obtained for cultivation of crops, excess water may percolate downward to recharge the permanent water table, reduce runoff and soil erosion and roots of crop plants can penetrate deeper to extract moisture from the water table.
c. **Clean tillage:** It refers to working of the soil of the entire field in such a way no living plant is left undisturbed. It is practiced to control weeds, soil borne pathogen and pests.
d. **Blind tillage:** It refers to tillage done after seeding or planting the crop (in a sterile soil) either at the pre-emergence stage of the crop plants or while they are in the early stages of growth so that crop plants (sugarcane, potato etc.) do not get damaged, but, extra plants and broad-leaved weeds are uprooted.
e. **Dry tillage:** Dry tillage is practiced for crops that are sown or planted in dry land

condition having sufficient moisture for germination of seeds. This is suitable for crops like broadcasted rice, jute, wheat, oilseed crops, pulses, potato and vegetable crops. Dry tillage is done in a soil having sufficient moisture (21-23%). The soil becomes more porous and softer due to dry tillage. Besides, the water holding capacity of the soil and aeration are increased. These conditions are more favourable for soil micro-organisms.

f. Wet tillage or puddling: The tillage operation that is done in a land with standing water is called wet tillage or puddling. Puddling operation consists of ploughing repeatedly in standing water until the soil becomes soft and muddy. Puddling creates an impervious layer below the surface to reduce deep percolation losses of water and to provide soft seed bed for planting rice. Puddling is done in both the directions for the incorporation of green manures and weeds. Wet tillage destroys the soil structure and the soil particles that aspirated during puddling settle later. Wet tillage is the only means of land preparation for transplanting semi-aquatic crop plant such as rice. Planking after wet tillage makes the soil level and compact. Puddling hastens transplanting operation as well as establishment of seedlings. Wet land ploughs or worn-out dry land ploughs are normally used for wet tillage.

12.7 Depth of Ploughing:

The desirable depth of ploughing is 12 to 20 cm for field crops. The ploughing depth varies with effective root zone of the crop. The depth of ploughing is 10-20 cm for shallow rooted crops and 15-30 cm for deep rooted crops.

A. Number of ploughing:

Number of ploughings depends on soil conditions, time available for cultivation between two crops and type of cropping systems. Zero tillage is practiced in rice fallow pulses. Minimum number of ploughings is taken up at optimum moisture level to bring favourable tilth depending on need of the crop.

B. Time of ploughing:

The optimum soil moisture content for tillage is 60% of field capacity.

12.8 Modern Concepts in Tillage:

Conventional tillage involves primary tillage to break open and turn the soil followed by secondary tillage to obtain seed bed for sowing or planting. With the introduction of herbicides in intensive farming systems, the concept of tillage has been changed. Continuous use of heavy ploughs creates hard pan in the subsoil, results in poor infiltration. It is more susceptible to run-off and erosion. It is capital intensive and increase soil degradation. To avoid these ill effects, modern concepts on tillage is in rule.

A. Minimum tillage: It aims at reducing tillage operations to the minimum necessity for ensuring a good seed bed. The advantages of minimum tillage over conventional tillage are,

- The cost and time for field preparation is reduced by reducing the number of field operations.
- Soil compaction is comparatively less.
- Soil structure is not destroyed.
- Water loss through run off and erosion is minimum.
- Water storage in the plough layer is increased. Tillage can be reduced in 2 ways.
- By omitting operations which do not give much benefit when compared to the cost.
- Bycombiningagriculturaloperationslikeseedingandfertilizerapplica tion. The minimum tillage systems can be grouped into the following categories,
- Row zone tillage:
- Primary tillage is done with mould board plough in the entire area of the field; secondary tillage operations like discing and harrowing are reduced and done only in row zone.
- Plough plant tillage:
- After the primary tillage, a special planter is used for sowing. In one run over the field, the row zone is pulverized, and seeds are sown by the planter.
- Wheel track tillage:
- Primary ploughing is done as usual. Tractor is used for sowing; the wheels of the tractor pulverize the row zone in which planting is done.
- In all these systems, primary tillage is as usual. However, secondary tillage is replaced by direct sowing in which sown seed is covered in the row zone with the equipment used for sowing.

B. Zero tillage (No tillage): In this, new crop is planted in the residues of the previous crop without any prior soil tillage or seed bed preparation, and it is possible when all the weeds are controlled by the use of herbicides. Zero tillage is applicable for soil swith a coarse textured surface horizon, good internal drainage, high biological activity of soil fauna, favourable initial soil structure and an adequate quantity of crop residue as mulch. These conditions are generally found in *Alfisols*, *Oxisols* and *Ultisols* in the humid and sub-humid tropics.

Till planting:

Till planting is one method of practicing zero tillage. A wide sweep and trash bar clears a strip over the previous crop row and planter opens a narrow strip into which seeds are planted and covered. Here, herbicide functions are extended. Before sowing, the vegetation present has to be destroyed for which broad spectrum non selective herbicides like glyposate, araquat and diquat are used.

Advantages:

- Zero tilled soils are homogenous in structure with a greater number of earthworms.
- Organic matter content increases due to less mineralization.

- Surface run-off is reduced due to presence of mulch. Disadvantages
- Higheramountofnitrogenhastobeappliedformineralizationoforganicmatterinzero tillage.
- Perennial weeds may be a problem.
- High number of volunteer plants and builds up of pests.

C. Stubble Mulch Tillage or Stubble Mulch Farming:

Soil is protected at all times either by growing a crop and by leaving the crop residues on the surface during fallow period.

Sweeps/ blades are generally used to cut the soil up to twelve to fifteen cm depth in the first operation after harvest and depth of cut is reduced during subsequent operations. When large number of residues are present, a disc type implement is used for the first operation to incorporate of the residues into the soil. This hastens the decomposition but still keeps enough residues on topsoil.

Two methods for sowing crops in stubble mulch tillage are,

a. Similar to zero tillage, a wide sweep and trash bars are used to clear a strip and a narrow planter shoe opens a narrow furrow into which seeds are placed.
b. A narrow chisel of 5-10 cm width is worked through the soil at a depth of 15-30 cm leaving all plant residues on the surface. The chisel shatters the tillage pans and surface crusts. Planting is done with special planters.

Disadvantages of stubble mulch farming:

- The residues left on the surface interfere with seed bed preparation and sowing operations.
- The traditional tillage and sowing implement or equipments are not suitable under these conditions.

D. Conservation Tillage:

The major objective is to conserve soil and soil moisture. It is a system of tillage in which organic residues are not inverted into the soil such that they remain on surface asprotectivecoveragainsterosionandevaporationlossesofsoilmoisture. If stubble forms the protective cover on the surface, it is usually referred to as stubble mulch tillage. The residues left on soil surface interfere with seed bed preparation and sowing operations. It is a year-round system of managing plant residue with implements that undercut residues, losses the soil and kills the weeds. Advantages

- Energy conservation through reduced tillage operations.
- Improve the soil physical properties.
- Reduce the water runoff from fields.

12.9 Main Field Preparation:

Tillage operations are generally classified in to two, preparatory cultivation and after cultivation. The preparatory cultivation or tillage is operations that are done before the cultivation. This preparatory cultivation is generally called as main field preparation. The main field preparation involves three processes, viz., primary tillage, secondary tillage and lay-out for sowing. Some of the important primary tillage implements are country plough, mould board plough, disc plough, chisel plough etc. Cultivators and harrows are generally used for secondary tillage purpose. However, in practical means, the first two (primary and secondary tillages) may not have any key difference, since; both operations are mainly carried out with same implement. Country plough and cultivators are used for both the purposes. After thorough ploughing, the field modified in to suitable way for planting such as ridges and furrows or beds and channels or pit according to the need of the crops. Such field modifications are mandatory for better crop production.

Photo Source:

www.cropwatch.unl.edu

https://agritech.tnau.ac.in/agriculture/agri_tillage_modernconcepts.html

Figure 12.1: Stubble mulch Tillage

Figure 12.2: Till planting

12.10 References:

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