**Techniques of Dry Land Agriculture**

**SOIL MOISTURE CONSTRAINTS**

Inadequate soil moisture availability is the major constraint in dry farming. All the above factors directly and indirectly affect the soil moisture. Availability of soil moisture to crops is affected by rainfall behavior as well as by various soil properties

• Shallow soils, degraded soils, eroded soils, gravelly soils and coarse textured soils have poor water holding capacity and hence cannot store much of rainfall.

 • Wind and water erosion remove the finer soil particles and expose the hard, impermeable subsoil causing less infiltration and less water storage.

• Crusting of soil surface after rainfall reduces infiltration and storage of rainfall, due to high run off.

• Compaction in surface and sub soil hardpans and poor soil structure affect infiltration and water storage.

• Poor organic matter content adversely affects soil physical properties related to moisture storage

**1 Methods of Soil Moisture Conservation**

**They are grouped as follows**:

1. **By adapting proper tillage**
2. **Control of run off water and soil erosion**
3. **Recycling of rain water**
4. **Reducing loss of soil moisture by mulching and antitranspirants**
5. **By increased rainfall use efficiency**
6. **Tillage**

Tillage may be described as the practice of modifying the state of the soil in order to provide conditions favourable to crop growth.

**The objectives of tillage in dry lands are to:**

 **•** Develop desired soil structure for a seedbed, which allows rapid infiltration and good retention of rainfall.

**•** Minimize soil erosion by following practices as contour tillage, tillage across the slope etc.

**•** Control weeds and remove unwanted crop plants.

**•** Manage crop residues, through mixing of trash is desirable for achieving good tilth and decomposition of residues. However, the retention of trash on top layers is also useful in reducing erosion. On the other hand, complete coverage of residues sometimes necessitates control of insects or to prevent interference with precision planting operations.

**•** Obtain specific soil configurations for in situ moisture conservation, drainage, planting etc.

**•** Incorporate and mix manures, fertilizers, pesticides or soil amendments into the soil.

**•** Accomplish segregation by moving soil from one layer to another, removal of rocks or root harvesting.

Hence, attention must be paid to the depth of tillage, time of tillage, direction of tillage and intensity of tillage

**(A) Depth of tillage**

 The depth of tillage depends on soil type, crop and time of tillage. Deep tillage of 25–30 cm is beneficial for deep heavy clay soils to improve permeability and to close cracks formed while drying. In soils with hard pans, deep tillage once in 2–3 years with chisel plough up to 35–45 cm depth at 60–120 cm interval will increase effective depth for rooting and moisture storage. Deep tillage is preferable for cotton, red gram and other deep-rooted crops. It is not recommended for shallow, gravelly, light textured soils.

**Medium deep tillage** of 15–20 cm depth is generally sufficient for most soils and crops. It is recommended for medium deep soils, shallow rooted crops, soils with pan free horizon and for stubble incorporation.Shallow tillage up to 10 cm is followed in light textured soils, and shallow soils and in soils highly susceptible to erosion. In soils prone for surface crusting, shallow surface stirring or shallow harrowing is useful

**(B) Time of tillage** - Early completion of tillage is often helpful to enable sowing immediately after rainfall and before the soil dries up. Summer tillage or off-season tillage done with preseason rainfall causes more conservation of moisture and also enables early and timely sowing. It is particularly useful for pre-monsoon sowing.

 **(C) Direction of tillage** - For moisture conservation, ploughing across slope or along contour is very effective. Plough furrows check the velocity of runoff, promote more infiltration when water stagnates in the depressions caused by plough furrows and improves soil moisture storage.

 **(D) Intensity of tillage** - It refers to the number of times tillage is done. Frequent ploughing in shallow light textured soils will pulverize the soils into fine dust and increase the susceptibility to erosion. In heavy soils, leaving the land in a rough and cloddy stage prior to sowing is useful for more depression storage. The concept of minimal tillage is also practiced in dry lands. Here tillage is confined to seeding zone only and the inter-space is not tilled. It not only saves time, energy and cost but also helps moisture conservation.

 **(E) Modern concept of tillage** - In dry lands, rainfall is received simultaneously over a large area. In order to ensure timely sowing before soil dries up, the interval between land preparations and sowing must be narrowed down. This calls for completion of tillage over a large area in quick time. Dependence on bullock power and traditional wooden plough may not help in this regard. Use of more efficient tillage implements and mechanization of tillage operations are warranted. Tillage in dry lands also encompasses land shaping for in situ soil moisture conservation. Implements that can carryout tillage and land shaping in one single operation will help in saving time and cost. If land preparation, land shaping and sowing can be done in one single operation it can save considerable time. This is termed as once over tillage, plough planting or conservation tillage. Suitable tractor drawn machinery like a broad bed former cum seeder, basin lister cum seeder, which can complete the land shaping and sowing simultaneously, can be used:

**(i) Minimum/optimum/reduced tillage**:

The objectives of these systems include

 (a) reducing energy input and labor requirement for crop production,

(b) conserving soil moisture and reducing erosion,

 (c) providing optimum seedbed rather than homogenizing the entire soil surface, and (d) keeping field compaction to minimum.

 **(ii) Conservation/mulch tillage:** The objectives are to achieve soil and water conservation and energy conservation through reduced tillage operations. Both systems usually leave crop residue on the surface and each operation is planned to maintain continuous soil coverage by residue or growing plants. The conservation tillage practices may advance some of the goals of alternative farming such as increasing organic matter in soil and reducing soil erosion, but some conservation tillage practices may increase the need for pesticides. Conservation tillage changes soil properties in ways that affect plant growth, and reduce water runoff from fields. The mulched soil is cooler and soil surface under the residue is moist, as a result many conservation tillage systems have been successful.

**(iii) Zero tillage or no-till system:** Here, the crop residue is usually shredded and planting is done without pre tillage. No till planting has problem of adequate weed control.

**Soil erosion and runoff**

Detachment and transport of soil and soil material caused by water and wind are widely prevalent in dry farming regions. Erosion takes place in both red soils and black soils. Soil and water are the most critical basic resources, which must be conserved as effectively as possible. No phenomenon is more destructive than soil erosion through which fertile topsoil and rainwater are lost. Erosion removes topsoil and exposes hard impermeable sub soil, increasing the chances of more run off. Erosion adversely affects soil physical properties such as loss of structure, reduced infiltration, soil depth and soil moisture storage capacity. Loss of topsoil through erosion leads to loss of plant nutrients and poor soil fertility.

**Soil erosion**:

Soil erosion is the process of detachment of soil particles from the topsoil and transportation of the detached soil particles by wind and/or water. The detaching agents are falling raindrop, channel flow and wind. The transporting agents are flowing water, rain splash and wind.

**Types of erosion**

**(a) Geological erosion**: It is said to be in equilibrium with the soil forming process. It takes place under natural vegetative cover completely undisturbed by biotic factors. This long time slow process has developed the present topographic features like stream channels, valleys, etc., through weather abnormalities such as intensive rainfall and biotic interference.

**(b) Accelerated erosion**: It is due to disturbance in natural equilibrium by the activities of man and animals through land mismanagement, destruction of forests, overgrazing, etc. Soil loss through erosion is more than the soil formed due to soil forming process.

**(c) Water erosion**: Water and wind are the main agencies responsible for soil erosion. Loss of soil from land surface by water, including runoff from melted snow and ice is usually referred to as water erosion. The major erosive agents in water erosion are impacting raindrops and runoff water flowing over the soil surface. Erosion and sedimentation embody the processes of detachment, transportation and deposition of soil particles.

**(i) Forms of water erosion:** Sheet, Rill, gully, ravine, landslide and stream bank erosion

**(ii) Factors affecting water erosion:** • Rainfall – amount, intensity, duration and distribution

• Soils – primary particle size, distribution, organic matter, structure, Fe and Al oxides, initial moisture content

• Topography – nature and length of slope

• Soil surface cover – plant canopy or mulches

 • Biotic interference – disturbance of natural balance

 **Losses due to erosion**: The losses due to erosion are loss of fertile top soil, loss of rain water, nutrient losses, silting up of reservoirs, damage to forests, reduced ground water potential, damage to reservoirs and irrigation channels and adverse effect on public health. (iv) Water erosion control: Water erosion can be minimized by preventing the detachment of soil particles and their transportation.

**Principles of water erosion control are:**

 **•** Maintenance of soil infiltration capacity

• Soil protection from rainfall

• Control of surface runoff

• Safe disposal of surface runoff Control measures are grouped in to agronomic, mechanical and forestry measures.

 **Agronomic**: Choice of crops, land preparation, contour cultivation, strip cropping, mulching, application of manures and fertilizers and appropriate cropping systems.

**Mechanical:** Contour bunding, graded bunding, bench terracing, contour trenching, gully control and vegetative barriers**.**

**Forestry**: Perennial trees and grasses.

**Wind erosion** - Erosion of soil by the action of wind is known as wind erosion. It is a serious problem on lands devoid of vegetation. It is more common in arid and semiarid region. It is essentially a dry weather phenomenon stimulated by soil moisture deficiency. The process of wind erosion consists of three phases: initiation of movement, transportation and deposition.

**Forms of wind erosion**: Transportation of soil particles by wind takes place in three ways.

 **Saltation**: Movement of soil particles by a short series of bounces along the ground surface. **Suspension**: Movement of fine dust particles, smaller than 0.1mm dia floating in the air.

 **Surface creep**: Rolling and sliding of soil particles along the ground surface due to impact of particles descending and hitting during saltation is called surface creep.

(**ii) Factors affecting wind erosion:**

The factors are soil clodiness, surface roughness, water stable aggregates and surface crust (Mechanical stability), wind and soil moisture (surface is dry or slightly moist), field length, vegetative cover, organic matter (cementing), topography and soil type (sand erodes easily).

**(iii) Losses due to wind erosion**: Fertile topsoil is lost. Fertile soils are converted into unproductive sandy soils drifting sand. Yield losses due to abrasive action of wind driven soil particles, especially on broad leaved crops.

(**iv) Wind erosion control**: Greatest damage by wind erosion occurs during summer months in dry regions, where soil surface is bare and wind velocity is at its peak.

**Basic principles of wind erosion control are**:

• Reducing wind velocity at ground surface, sufficient to prevent it being able to pickup soil particles.

• Increasing the size of soil aggregates or covering the soil with a non-erodable surface.

• Trapping the saltating soil particles.

• Keeping the soil moist so that soil particles moving by saltation loose their momentum at the surface.

1. **In situ moisture conservation techniques**

**• Cultural/agronomic methods**

**• Mechanical methods**

**• Agrostological/biological methods**

**1. Cultural /Agronomical methods**

**(i) Addition of organic matter:** By improving soil physical properties and water holding capacity.

**(ii) Off season/summer tillage**: Plough furrows can hold water in the depressions and thereby increase the infiltration. When done across the slope, the plough furrows check runoff, reduce the velocity of runoff water and improve storage. Summer tillage is a traditional practice helps in the storage of pre-sowing rainfall. When ploughing is done along contour, it is termed as contour ploughing and is more helpful for in situ moisture conservation. Summer ploughing also helps in control of perennial weeds, pest control and enables early sowing with onset of rains.

**Contour farming:** Ploughing along the contour and sowing reduce soil erosion and reduce runoff. For e.g., Jowar sown in the black soils on contour line restricts the run off to 13.7% of the total rainfall and soil loss to 2.4 t/ha/year**.**

**Cover crops**: Erosion will be reduced if the land surface is fully covered with foliage. e.g., black gram, green gram, groundnut and fodder grasses like Cenchrus ciliaris, Cenchrus glaucus, dinanath grass, marvel grass. Both contour cropping and cover cropping can be practiced when the slope is less than 2 per cent.

1. **Mixed cropping. 2) Inter cropping, 3) Mulching**

**Strip cropping**: Strip intercropping involves erosion resistant crops and erosion permitting crops in alternate strips of 2–3 m width across slope and along the contour. Erosion resistant crops include grasses and legumes with rapid canopy development. For example, Cenchrus glaucus + Stylosanthes hamata.

**2. Mechanical methods**

**The basic principle are:** (i) shaping the land surface manually or with implements in such a way as to reduce the velocity of runoff.

 (ii) to allow more time for rainfall to stand on soil surface.

 (iii) to facilitate more infiltration of rainfall into soil layers. Choice of any particular method under a given situation is influenced by rainfall characters, soil type, crops, sowing methods and slope of land.

**1) Basin listing:** Formation of small depressions (basins) of 10–15 cm depth and 10–15 cm width at regular intervals using an implement called basin lister. The small basins collect rainfall and improve its storage. It is usually done before sowing. It is suitable for all soil types and crops**.**

**2) Bunding:**

Formation of narrow based or broad based bunds across slope at suitable intervals depending on slope of field. The bunds check the free flow of runoff water, impound the rainwater in the inter-bund space, increase its infiltration and improve soil moisture storage. Leveling of inter-bund space is essential to ensure uniform spread of water and avoid water stagnation in patches**.**

**It can be classified into three types:**

**a) Contour bunding:** Bunds of 1 m basal width, 0.5 m top width and 0.5 m height are formed along the contour. The distance between two contour bunds depends on slope. The interbund surface is leveled and used for cropping. It is suitable for deep red soils with slope less than 1%. It is not suitable for heavy black soils with low infiltration where bunds tend to develop cracks on drying. Contour bunds are permanent structures and require technical assistance and heavy investment**.**

**b) Graded/field bunding:**

Bunds of 30-45 cm basal width, and 15-20 cm height are formed across slope at suitable intervals of 20-30 m depending on slope. The inter-bund area is leveled and cropped. It is suitable for medium deep-to-deep red soils with slopes up to 1%. It is not suitable for black soils due to susceptibility to cracking and breaching. Bunds can be maintained for 2-3 seasons with reshaping as and when required**.**

**Compartmental bunding:**

Small bunds of 15 cm width and 15 cm height are formed in both directions (along and across slope) to divide the field into small basins or compartments of 40 sq. m. size (8 × 5 m). It is suitable for red soils and black soils with a slope of 0.5-1%. The bunds can be formed before sowing or immediately after sowing with local wooden plough. It is highly suitable for broadcast sown crops. CRIDA has recommended this method as the best in situ soil moisture conservation measure for Kovilpatti region of Tamil Nadu. Maize, sunflower, sorghum performs well in this type of bunding.

**1)Ridges and furrows:**

Furrows of 30-45 cm width and 15-20 cm height are formed across slope. The furrows guide runoff water safely when rainfall intensity is high and avoid water stagnation. They collect and store water when rainfall intensity is less. It is suitable for medium deep-todeep black soils and deep red soils. It can be practiced in wide row spaced crops like cotton, maize, chillies, tomato etc. It is not suitable for shallow red soils, shallow black soils and sandy/ gravelly soils. It is not suitable for broadcast sown crops and for crops sown at closer row spacing less than 30 cm. Since furrows are formed usually before sowing, sowing by dibbling

or planting alone is possible. Tie ridging is a modification of the above system of ridges and furrows where in the ridges are connected or tied by a small bund at 2–3 m interval along the furrows. Random tie ridging is another modification where discontinuous furrows of 20–25 cm width, 45–60 cm length and 15 cm depth are formed between clumps or hills of crops at the time of weeding. Yet another modification of ridges and furrows method is the practice of sowing in lines on flat beds and formation of furrows between crop rows at 25–30 DAS. This enables sowing behind plough or through seed drill.

 **(iv) Broad Bed Furrow (BBF**): Here beds of 1.5 m width, 15 cm height and convenient length are formed, separated by furrows of 30 cm width and 15 cm depth. Crops are sown on the beds at required intervals. It is suitable for heavy black soils and deep red soils. The furrows have a gradient of 0.6%. Broad bed furrow has many advantages over other methods.

**•** It can accommodate a wide range of crop geometry i.e., close as well as wide row spacing**.**

**•** It is suitable for both sole cropping and intercropping systems**.**

**•** Furrows serve to safely guide runoff water in the early part of rainy season and store rainwater in the later stages**.**

**•** Sowing can be done with seed drills.

**•** It can be formed by bullock drawn or tractor drawn implements. Bed former cum seed drill enables BBF formation and sowing simultaneously, thus reducing the delay between rainfall receipts and sowing**.**

 **(v) Dead furrow-** At the time of sowing or immediately after sowing, deep furrows of 20 cm depth are formed at intervals of 6–8 rows of crops. No crop is raised in the furrow. Sowing and furrowing are done across slope. It can be done with wooden plough in both black and red soils.

**3)Agrostological methods**

The use of grasses to control soil erosion, reduce run off and improve soil moisture storage constitutes the agrostological method. Grasses with their close canopy cover over soil surface and profuse root system, which binds soil particles, provide excellent protection against runoff and erosion. The following are the various agrostological methods of in situ moisture conservation.

**a) Pastures/grass lands**: Raising perennial grasses to establish pastures or grass lands is recommended for shallow gravelly, eroded, degraded soils. Grass canopy intercepts rainfall, reduces splash erosion, checks runoff and improves soil moisture storage from rainfall.

**b) Strip cropping with grasses:** Alternate strips of grasses and annual field crops arranged across slope check runoff and erosion and help in increasing moisture storage in soil.

**c)Ley farming**: It is the practice of growing fodder grasses and legumes and annual crops in rotation. Grasses and legumes like Cenchrus, stylo are grown for 3–5 years and followed by annual crops like sorghum for 2 year. When the field is under grasses or legumes, soil moisture conservation is improved.

**d)Vegetative barriers**: Vegetative barrier consists of one or two rows of perennial grasses established at suitable interval across the slope and along the contour. It serves as a block to free runoff and soil transport. Vetiver, Cenchrus etc., are suitable grasses. Vetiver can be planted in rows at intervals of 40 m in 0.5% slope. Plough furrows are opened with disc plough first before commencement of monsoon. 5–8 cm deep holes are formed at 20 cm interval and two slips per hole are planted in the beginning of rainy season. The soil around the roots is compacted. Vetiver barriers check runoff and prevent soil erosion. While they retain the soil, they allow excess