**Recycling of rainwater**

Runoff is that portion of precipitation, which makes its ways towards stream, channel, lake or ocean as surface flow. Mostly runoff refers to surface flow only. Runoff from rainfall is inevitable and cannot be completely arrested. In dry farming areas, rainfall often occurs at high intensity, which exceeds the infiltration rate and causes runoff. Also, when quantity of rainfall exceeds the water holding capacity of soils, runoff has to take place. In certain instances, surface characteristics of soils also cause runoff. Usually, under unchecked conditions, about 40% of rainfall may be lost as runoff. Even if moisture conservation practices are adopted, about 10–15% of rainfall in black soils and about 20% of rainfall in red soils is lost as runoff. The amount of such runoff varies with rainfall intensity, soil physical properties, soil surface characters, slope, vegetation cover and cultural practices. Runoff water, if not checked, flows out and is wasted, causing soil erosion. It can be guided, collected and recycled to augment water availability to rainfed crops. The collection, storage and recycling of runoff water constitute the process of water harvesting. Water harvesting can be viewed from two situations. First is a case of normal rainfall with high intensity on a few rainy days causing runoff. This runoff can be guided and collected in storage structures called farm ponds and reused for supplemental irrigation to crops suffering from moisture stress. This is termed as macro watershed approach or macro catchment water harvesting. In the second instance, total rainfall is less and soil storage is inadequate for supporting crop growth. Here part of the land is left barren and uncultivated. This is known as donor area and is treated in such a way as to increase runoff from rainfall. **The runoff from the donor strip is directed towards the lower adjacent strip to increase soil moisture storage there. This strip is used for raising crops. This is called as micro watershed approach or micro catchment water harvesting.**

**(i) Water harvesting through farm ponds**: The collection of rainwater and storing in big farm ponds is not a new concept in India. It is in vogue since early days in the form of tanks. Farm ponds are small storage structures constructed at the lowest point of a farm to collect and store runoff water. Runoff from various parts of the catchment area is properly guided through grassed waterways into the farm pond. The following points need to be considered while constructing farm ponds.

 • Deep heavy soils with low permeability are better suited for farm pond technology than shallow light soils with high permeability. But, ironically, the usefulness of farm pond is more felt in light soils with low water storage capacity.

• Farm pond has to be constructed at the lowest point of the farm to collect runoff water from the entire farm area.

• Size of farm pond depends on rainfall quantity, soil type, area of catchment (farm size) and estimated runoff.

• Provisions for arresting soil inflow into the pond at the inlet point and a weir, for draining excess water when pond is full have to be made.

• Runoff has to be guided to the farm pond through grassed waterways.

• Water loss through seepage and, evaporation has to be checked. Seepage loss, can be reduced by lining the sides and bottom with soil + sand + cement or soil + cow dung + straw, spraying sodium chloride or sodium carbonate on the surface. Evaporation loss can be reduced by floating materials to prevent direct exposure of water surface, changing the shape of the pond to provide more depth rather than surface area (circular instead of rectangular).

**Advantages** - Harvested water can be used for protective irrigation to crops at critical stages. Since runoff is properly guided through grassed waterways, erosion is checked. Earth excavated from ponds can be used for bunding and leveling of fields. Stored water can be used as drinking water for humans and animals, for spraying operations and for fish rearing. High value tree crops can be raised near farm ponds with protective irrigation. A chain of farm ponds can recharge ground water in the region.

**a) Water harvesting under deficit rainfall**: The situation here is that the seasonal rainfall quantity by itself is not sufficient to support a crop till maturity. Therefore, runoff of rainfall from a part of the land left uncultivated is directed to an adjacent strip, which alone is used for cropping. In this strip (run-on strip/recipient area), the rainfall falling on its surface is supplemented by runoff directed from the other strip of land (donor area/runoff strip) and total water supply available is increased to facilitate cropping. This can be accomplished by the following practices. A portion of the field in the upper reach is left uncultivated. It is shaped or treated to increase runoff. This can be accomplished by covering the surface with polythene films or by water proofing it by spraying sodium carbonate or water repellant materials like silicone/asphalt or by shaping the land into a sloping, clear, smooth, compact surface to increase runoff. Runoff from this donor strip is guided to a smaller, strip on the lower reach to increase soil storage and to raise crops. The proportion of ‘donor area’ to cropped area depends on rainfall quantity, duration of rainfall, soil properties and crop characters. In the cropped area, land is shaped to conserve moisture. Acceptability of this method is however limited in regions where pressure on land does not permit leaving a large area barren for runoff harvesting.

**Reduction of loss of stored soil moisture Rainfall infiltrates** into the soil and permits downward and laterally and gets stored in soil profile. Part of it percolates down to ground water. Stored water is absorbed by plants and weeds. It is lost from the soil surface as evaporation and from crop and weed canopy as transpiration. The loss through evaporation from soil and transpiration by weeds can be checked to reduce loss of stored moisture. Excessive transpiration loss from crop plants can also be minimized. ET loss is by latent heat of vapourisation and is governed by energy, vapour pressure gradient and conductivity of medium. Evapotranspiration can be checked by:

• Minimizing the evaporative surface area

• Minimizing the energy need to the evaporative site

 • Minimizing the diffusivity/conductivity of water movement from soil

• Minimizing the driving force or potential that is responsible for upward movement of water.

**Reduction of evaporation loss Evaporation** happens to maintain soil thermal regime and is governed by soil moisture content, vegetative cover on surface, soil type, temperature gradient between soil and atmosphere and atmospheric water demand. Higher soil moisture content, especially a wet surface soil increases evaporation rate. As the surface soil dries up, continuity of capillary pores is disrupted and moisture movement upwards from deeper layers is reduced. Soil surface that is exposed to radiation without any vegetative cover offers more scope for evaporation due to overheating. Evaporation loss in a cropped field is more in the early growth stage when canopy cover is less, especially in widely spaced crops and slow growing species. Vegetative cover prevents direct exposure of soil surface to radiation, reduces heating of soil layers and thus checks the necessity for evaporation. Black soils tend to absorb more heat and may evaporate more water. When cracks are formed during drying, evaporation takes place from the sides of the cracks also. With high temperature, low humidity and dry winds, atmospheric water demand increases the rate of evaporation.

**(a) Measures to reduce evaporation loss**

**(i) Shallow surface tillage**: When surface soil is stirred by tillage, the continuity of capillary pores is broken and the rise of water through capillary movement is obstructed. Shallow tillage after summer showers is beneficial in this regard. This process is called dust mulching. Inter tillage between crop rows during early dry spells has a similar effect.

 **(ii) Mulching**: Mulching means covering the soil surface with any material such as organic wastes, plastic, polythene sheets etc. The organic wastes used for mulching include crop stubbles, straw, coir pith, groundnut shell, husk etc. These wastes at 5–10 t ha−1 are spread on the soil surface to a thickness of 5-10 cm**.**

**Mulching provides the following benefits**:

**• reduces direct impact of rain drops on soil particles and controls splash erosion.**

**• increases infiltration.**

**• reduces velocity of runoff water.**

**• controls erosion.**

**• improves soil moisture storage from rainfall.**

**• controls evaporation loss.**

**• suppresses weed growth.**

**• influences thermal regime of soil by reducing soil temperature.**

**• improves microbial activity.**

**• controls salinity development.**

**• can be incorporated as manures later.**

**Vertical mulching** is a technique where in trenches of 40 cm wide, 15 cm deep are dug at 2–4 m interval across slope and filled with stubbles or organic wastes to a height of 10 cm above soil surface. Runoff is checked, collected in the shallow trenches and redistributed to adjoining soil layers.

L**ive mulching** is the term used to describe the covering soil surface through the plant canopy in intercropping system. e.g., sorghum + forage cowpea, sorghum + sword bean.

**Dust mulching** refers to the soil condition associated with tillage. When land is ploughed or stirred, the surface soil is disturbed and this breaks the continuity of capillary pores from subsoil to surface. As a result, evaporation is checked and soil moisture is conserved. Guntaka (Blade harrow)/Danti/hand hoe are the implements used for dust mulching. Stover mulch or straw mulch refers to covering the soil surface with cumbu/sorghum straw, sugarcane trash reduces the evaporation and increases soil moisture efficiency. Similarly mulching with organic waste, crop residues, plastic material can be done. **Antitranspirants**

 Antitranspirants are substances or chemicals applied on plant-foliage to control rate of transpiration. The important points to be considered in using antitranspirants are:

**(a)** They should restrict water loss from leaf surface without restricting entry of carbon dioxide for photosynthesis, and

 **(b)** Transpiration necessary for cooling of leaf surface should not be completely stopped by the application of antitranspirants leading to rise in leaf temperature. Based on their mechanism of action, antitranspirants are classified into various types.

 **Stomatal closing type:** They cause partial or complete closure of stomata by inducing the guard cells to close. But complete closure of stomata adversely affects gas exchange and photosynthesis. These chemicals may also cause phyto-toxicity and are very expensive too. E.g., Phenyl mercuric acetate (PMA) and alkanyl succinic acid (ASA).

**Film forming type**: They cover the stomata by forming a thin film over leaf surface. These substances are nontoxic, non-degradable and very easy to apply but they adversely affect photosynthesis. E.g., Paraffin and wax emulsions, folic 2%, and power oil 1%.

**Reflectant type**: When sprayed on leaf surface, the reflectant type antitranspirants increase the leaf albedo or leaf reflectance of sunlight. As a result, heating is reduced, leaf temperature inside is low and need for transpiration is reduced. E.g., Kaolin and lime solution. Spraying kaolin at 3–6% concentration reduced leaf temperature by 3–4 °C and transpiration by 22–28%. These are less expensive, non-phytotoxic and do not interfere with photosynthesis, since stomatal closure does not take place. Growth retardant type: Chemicals like cycocel (ccc-chloro choline chloride, chlor mequat) when sprayed on foliage, reduce leaf area and thereby reduce the transpiring area and transpiration.

**B. Cultural methods**

 **(a) Weed control**: Most weeds have a high transpiration coefficient i.e., amount of water transpired to produce unit quantity of dry matter. Early weed control prevents unwanted transpiration loss through weeds**.**

**(b) Shelterbelts**: Rows of trees grown across the direction of wind reduce air movement, reduce temperature of air and plant canopy, increase humidity in the protected strips and thereby reduce the atmospheric water demand and control transpiration in the inter space between shelterbelts.

**(c) Alley cropping**: This practice refers to raising perennial shrubs or tall crops as hedge rows up to 1-2 m height at 48 m intervals and raising short stature annual crops in the alleys (inter space between hedge rows). A similar effect on reduction in atmospheric water demand and transpiration as described under shelterbelts is caused in alley cropping. This method is also called as hedgerow intercropping. e.g.,

**VI. Rainfall use efficiency (RUE) The** rainfall use efficiency is defined in many ways. The most common definition is WUE. WUE = Dry weight produced/ET WUE as the ratio of water used (ET) to the water potentially available (Rainfall + stored moisture).